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BUREAU OF NAVAL WEAPONS

For OTS

BASIC GOALS

It is necessary to establish needs for improved performance, greater lethality, longer ranges, higher speeds, improved maneuverability, reduced countermeasure susceptibility, and the like. But there are other important needs which must also be recognized such as lower cost, greater simplicity, higher reliability, and easier operation and maintenance. Every aspect of our planning for the future must place greater emphasis on the requirements for all needs.

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FOREWORD

The task of providing the Navy with effective and versatile aircraft and weapons is the responsibility of the Bureau of Naval Weapons. The Bureau of Naval Weapons plans, directs, and coordinates the necessary research, development, and production of these weapons.

The technical problems presented in this report range through a broad area of needs in many scientific and engineering fields. Each problem presented is one in which the Bureau of Naval Weapons actively is seeking a solution.

In making these research needs known to Industry, the Bureau of Naval Weapons hopes to learn of new developments and problem solutions which may exist but of which the Bureau is not aware. Despite extensive research programs within the Bureau establishment, there is a continuing need for fresh approaches, ideas, and techniques which may lead to superior aircraft and weapons. The information in this publication is intended to stimulate research and development based on the requirement that solutions to the problems are needed for the defense of our nation.

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INTRODUCTION

The problems outlined in this report are those unclassified problems which first appeared in NAVORD REPORT 6515 (a Bureau of Ordnance publication). In addition, certain problems which were of specific interest to the technical codes of the Bureau of Aeronautics also have been included, reflecting the merger of the Bureau of Aeronautics and the Bureau of Ordnance. Recently all problems have been reviewed for adequacy, accuracy, and validity by the Bureau of Naval Weapons.

The solution to a number of problems outlined in this report may entail substantial expenditures of money and time. In some cases large sums of money have already been expended by the Bureau of Naval Weapons in search for a solution. The reason for including problems of this type in this report is the hope that industry may have a completely new approach or an adaptable technique that could be the key to solving important problems of wide scope.

Other problems in this report are those involving simply an advancement in the state-of-the-art. Improvements of this type can be an increase in useful property, a decrease in cost, or an advancement in the uniformity or reliability of products. The improvement of existing products by employing better material or better fabrication techniques is the natural role of Industry. The purpose of including these problems in this report is to inform Industry of the Bureau's needs in these fields.

A third type of problem is one which has an immediate application to a specific, current requirement. These problems are ones whose solutions or even partial solutions would be of immediate benefit but whose importance may not be generally appreciated.

The problems in this report have been divided into five chapters: Problems in Antisubmarine Warfare, Anti-Air Warfare, Strike Warfare, Support Equipment and Supporting Research. Although the casual reader of these problems is not likely to relate those in each category to specific warfare types or research efforts, their solution will, in fact, contribute directly to these areas. If an organization or individual is interested in research of a specific type, a Table of Contents and an Index have been provided which identify each problem by hardware involved and/or field of scientific endeavor.

Unclassified "Old" problems contained in the previous editions of NAVWEPS REPORT 7682, Volume I, that are still valid appear in the first part of Volume I of this edition (NAVWEPS REPORT 7682A) and retain their original numbers. Problems in the second part of this report have been submitted recently by Bureau of Naval Weapons field activities and are designated "New" problems. These unclassified "New" problems have been numbered serially starting with number 121.

Volume II of NAVWEPS REPORT 7682A, which presents classified problems, is arranged in a similar fashion. The first part contains "Old" classified problems 121 through 205 from the previous edition of NAVWEPS REPORT 7682. These problems have been renumbered 1121 through 1205 to differentiate them from the problems added to Volume I. "New" classified problems presented in the second part of Volume II begin at problem number 1206. Volume II is classified CONFIDENTIAL. To obtain a copy of this portion of NAVWEPS REPORT 7682A, interested scientific and engineering groups must meet the following requirements:

a. Have the necessary technical competence to engage in research and development work.

b. Possess a current Department of Defense Industrial Facility Security Clearance to the level of CONFIDENTIAL.

c. Have executed the Department of the Navy Policy Agreement.

In this document the Bureau has defined problems for which it is actively seeking solutions and consolidated them into a Research Problems Document. PROPOSED SOLUTIONS, SUPPORTED BY TEST DATA, SHOULD BE SUBMITTED TO THE BUREAU FOR EVALUATION FOR POSSIBLE ADDITIONAL STUDY EFFORT. SUCH PROPOSED SOLUTIONS SHOULD DEMONSTRATE THAT AN ANSWER TO A SPECIFIC PROBLEM IS AT HAND OR THAT A WORTHWHILE APPROACH HAS BEEN SUFFICIENTLY EXPLORED TO SHOW A HIGH PROBABILITY OF SUCCESS. PROPOSALS FOR RESEARCH AND DEVELOPMENT CONTRACTS TO STUDY OR DEVELOP SOLUTIONS TO THE PROBLEMS ARE NOT SOUGHT. THIS DOCUMENT SHOULD NOT BE CONSTRUED AS A REQUEST FOR PROPOSALS, NOR AS COMMITMENT ON THE PART OF THE BUREAU OF NAVAL WEAPONS THAT A CONTRACT MAY BE ISSUED, NOR AS A REQUEST THAT ANY EXPENSES BE INCURRED IN ANTICIPATION OF GOVERNMENT CONTRACTS, NOR AS A BASIS FOR PROSECUTING A CLAIM AGAINST THE GOVERNMENT.

It is recognized that an organization or individual, while wishing to cooperate in advancing the technological capability of the Navy, may not desire to have certain data made public. Therefore, information received in connection with this document will be safeguarded to the extent desired by the originator. Information of a proprietary nature or to which patent privileges apply will not be disclosed without appropriate consent. To insure that submitted data is given the protection desired by the originator, it is requested that it be clearly marked and so stated in the letter of transmittal.

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Chief, Bureau of Naval Weapons
Department of the Navy
Washington 25, D. C.

Attn: Code RREN-1

Chapter 1

PROBLEMS IN ANTISUBMARINE WARFARE

PROBLEM NO. 1: DC Motor

Develop an electrically and acoustically silent dc motor.

BACKGROUND AND NEED: The present configuration and operating principles of dc motors permit the commutator to generate electrical noise which degrades electronic circuitry. Since batteries will continue to be used as power sources for torpedoes, a breakthrough in motor design is necessary if future weapons are to possess the sensitivity and performance characteristics considered essential.

PROBLEM NO. 2: O-Rings

Develop O-rings that are mutually compatible with lubricants at high speeds and temperatures, or develop O-rings that do not require lubrication. Conditions of use are:

a. Temperature up to 2200°F

b. Pressures up to 7000 psi

c. Rubbing speeds of 300 fps.

BACKGROUND AND NEED: Many lubricants in current use are composed largely or entirely of synthetic materials. While these synthetic lubricants provice satisfactory lubrication and corrosion prevention, they have a deteriorating effect on rubber and synthetic materials. (O-rings and gaskets).

Existing materials for O-rings (other than rubber) have a tendency to stiffen and spall after extended use. (Recent advances in silicone rubber O-rings have extended their operating range to 900°F.) The development of suitable lubricants which will not attack rubber O-rings or destroy the resiliency of synthetic O-rings would permit design of lube systems and hydraulic systems having extended service life with less maintenance. Present O-rings are not compatible with lubricants for more than one year even in static seals.

PROBLEM NO. 2 (Cont)

Present dynamic O-rings operate at pressures up to 500 psi but extrude at higher pressures, producing friction and heat which destroy the O-ring. Static O-rings are capable of operation at temperatures up to 1000°F but future applications, such as in solid propellant engines, will require seals that will operate at 2500°F. Lubricants must be capable of withstanding the same temperature or the O-rings must be capable of operation without lubrication. Regarding this latter approach, recent experience in the evaluation of O-rings for dynamic applications indicates that external lubrication should be avoided if at all possible. Research into the development of new materials that require no lubricants to function satisfactorily might be extremely worthwhile.

In addition to the above, a major difficulty in the use of present O-ring materials is the lack of data supplied by manufacturers on their products. Data is usually conflicting, incorrect or based upon specific applications. The coefficient of friction applicable to different materials are not available. Because of this lack of data, vast amounts of time are wasted in testing materials. An approach to the problem might be the standardization of O-ring materials into specific sizes and temperature ranges. Lubricants for specific groups of materials could then be developed.

PROBLEM NO. 3: Electrical Energy Sources

An order of magnitude improvement in batteries is essential for their future utilization as primary energy sources (torpedoes) and auxiliary energy sources. Several improvements in specific types of batteries, battery characteristics, or other energy sources are needed, as follows:

a. There is a need for a lightweight source of electrical power for torpedo propulsion. A battery that will provide 100 kilowatts for 15 minutes, 500 watt-hours per pound, and 19 watt-hours per cubic inch can be considered an ultimate goal.

b. A thermoelectric generator with the following characteristics is sought as an advancement in the state-of-the-art as a possible approach toward the ultimate objective. The characteristics given below are minimum and include the weights and volumes of all auxiliary equipment as well as the hull enclosing the power system. Such items

PROBLEM NO. 3 (Cont)

as fuels, oxidizers, tanks, thermoelectric generators, buss rods, pumps or pressure systems, combustion chambers, heat sinks, gas exhaust systems, voltage control systems and pressure hulls are included.

CHARACTERISTICS

Minimum watt-hour/lb = 20.6

Minimum watt-hour/in^3 = 1.0

Minimum watt/lb = 135.0

Minimum watt/in^3 = 7.0

It must be capable of rapid start-up, good voltage control ($\pm$ 2 percent if possible) and insensitive to operating depth.

c. A battery that will provide 10 kilowatts for 5 minutes (guided missile auxiliary power) -- 200 watt-hours per pound or 7.5 watt-hours per cubic inch.

d. A rugged dry cell capable of full capacity without activation after 10 years of shelf storage to 120°F.

e. A small, lightweight battery with the following characteristics: 1200 watts, 10 minutes operation, 30 volts $\pm$ 5 percent, total weight 2 pounds, 1 second activation time allowed (no prior warmup time and operation in the temperature range -65° to 165°F).

f. A small, lightweight battery that will provide 7 watts for 1 hour. It must have a shelf life of 5 years and require no activation procedure. Size should not be appreciably larger than 1 inch in diameter by 4 inches long.

g. Many applications require not only a very low constant current supply (at a constant voltage) but periodic surges also. Present batteries experience a large unacceptable voltage drop during these surges. A battery of minimum size and weight without this drawback is needed.

PROBLEM NO. 3 (Cont)

h. Develop a sea water battery that will produce 4 to 8 watt-hours per cubic inch during a 72-hour operating life.

i. Develop an energy source which accumulates a small amount of energy over a long period of time for an intermittent short time power requirement.

j. Develop a compact power source for projectile fuzes with the following characteristics: 1.5 inch cube, 0.6 - 1.7 - 170 volts; 2 watts; and life span of 2 minutes for tube operation.

k. A reduction in cost, volume, and weight of all types of batteries, coupled with an increase in reliability of activation and an improvement in quality control would be desirable.

l. Develop a miniature (1/2 inch diameter by 3/4 inch long) battery which can be activated in 50 milliseconds and produce 1/2 ampere, 1 volt, for a period of 30 to 40 seconds.

m. Develop a fuze battery with the following ratings: 2.0 volts at 0.5 amperes; and 100 volts at 50 milliamperes. It should possess the following characteristics: volume of 4 cubic inches, 0.5 second activation time, operation over a temperature range from -65°F to 165°F, voltage fluctuation ± 5 percent, and a useful life equal to a minimum of 2 minutes.

BACKGROUND AND NEED: Experience has shown that as essential performance and design improvements in Naval weapon systems become feasible, major improvements in the vital electrical systems of weapons are required. In view of the engineering evolution of weapon systems necessary for the Navy to accomplish its missions in the future, a transition from conventional electric power systems to the direct conversion of energy to electrical energy is necessary in many instances to provide adequate electric power for planned aircrafts, missiles, torpedoes, ASW systems, and satellites. These anticipated power requirements will require extensive investigation, applied research and engineering development of direct conversion of energy to provide useable electric power. These power requirements vary from a few milliwatts for special applications to several megawatts for a maneuverable space vehicle. Planned aircraft will have ample heat sources and fuel for thermoelectric or chemical-electric, conversion; however, missile, ASW, and space applications

will be largely dependent upon chemical, solar, or nuclear energy for conversion to electric power. Included in direct energy conversion processes needing state-of-the-art advancement are fuel cells, thermoelectrics, thermionics, solar cells, magnetohydrodynamics, regenerative galvanic systems, and high energy primary batteries, (order of 200 plus watt hours per pound). High capacity to weight ratios, high power density, high efficiency and reliability are important research attainments.

The field of underwater ordnance, with specific reference to mines and torpedoes, utilizes batteries as a basic energy source. The importance of developments in this field parallels the increased urgency of countering the growing submarine threat. Despite gains achieved through research and development, the situation in obtaining high-power, efficient, long shelf life batteries at a cost commensurate with their basic expendable nature is far from good.

The requirements cited in parts (a) and (c) of the problem statement are about 1000 to 2000 percent higher than the capabilities of present batteries. A good present day battery, e.g., the magnesium-silver chloride water activated type will give approximately 22.4 watt-hours per pound or 0.9 watt-hours per cubic inch. Effort in the development of ammonia vapor activated batteries or some other high rate system could conceivably lead to progress in the direction of the requirements cited in part (c).

Fuel cells of various types have shown promise in the laboratory as primary power supplies. At present they require too long a start-up time for most ordnance applications. A fuel cell operating for any length of time requires considerable auxiliary equipment (see requirements of part (b) of the problem statement). Greatly increased capabilities could minimize this disadvantage, however.

The lead acid storage battery is large, heavy and inexpensive. Since its power output is low, it is not attractive for ordnance use. While the silver-zinc battery is small and lightweight, it has a short shelf life after activation. Shelf life of many batteries can be prolonged by unactivated storage. The main difficulty encountered with unactivated storage is the need for immediately available power without any attention. Further, electrolyte storage outside the plate area (unactivated storage) increases the battery volume without increasing its output per cubic inch while the hardware associated with

PROBLEM NO. 3 (Cont)

activation increases the overall weight considerably and reduces the reliability of the battery system. Another disadvantage of separate electrolyte storage is that the unactivated battery is filled with gas (air, etc.) which must be bled off to obtain complete activation and capability when the electrolyte is introduced.

With reference to part (g) the voltage drop encountered in present batteries is caused by high internal resistance. Larger batteries which characteristically have lower internal resistance are prohibitive because of their size and weight. The required pulse energy could be stored in capacitors within the instrument package, but this would necessitate an increase in size and weight. The best approach, therefore, would probably be to lower the internal resistance in a battery of minimum size and weight.

A suggested approach for part (h) would be a thermal battery utilizing the chemical reaction with sea water for thermal input. With regard to part (k); reduction of cost, volume, and weight obviously does not go hand-in-hand with increased reliability. However, equal emphasis should be placed on objectives such as decreased cost, increased reliability, increased shelf life and increased quality control even at the sacrifice of some performance.

Existing techniques for part (l) of the problem use a thermal battery which is used in a parachute release mechanism for positive discharge of the parachute. The battery would fire a squib or generate a gas to actuate the piston. Existing thermal batteries have an operating life of about only 5 seconds.

PROBLEM NO. 4: Hydraulic Fluids

(Deleted)

PROBLEM NO. 5: Pump, Hydraulic, Silent

Develop a hydraulic pump of 25 peak horsepower for operation at pressures up to 5000 pounds per square inch that produces a minimum of noise in the sonic and ultrasonic bands (to 50 kilocycles).

PROBLEM NO. 5 (Cont)

BACKGROUND AND NEED: Future underwater weapon systems are directed toward higher speed and range and will use acoustic guidance and homing. A major restriction on these systems is the unavailability of noise-free components. Pumps are especially troublesome in this respect, and a particular problem exists in obtaining noise-free pumps of the type described.

PROBLEM NO. 6: Pump, Lightweight, All Purpose

Develop a lightweight pump (approximately 10 pounds) with the following performance characteristics:

a. Speed - up to 8000 rpm,
b. Pressure - up to 3000 psi,
c. Flow rate - 30 to 40 gal/min,
d. Capable of pumping sea water, oxidizers, and fuels.

BACKGROUND AND NEED: This pump is needed for torpedo applications where present fuel displacement units are much too heavy.

PROBLEM NO. 7: Speed Reducer

Develop a high torque, 50-to-1 speed reducer using gears or other mechanisms that operate at extremely high efficiency and develop a minimum of noise in the sonic and ultrasonic bands (to 50 kilocycles). The speed reducer should be capable of handling power levels of 50 to 1000 horsepower. Present reducers weigh 0.5 pound or less per horsepower per output-shaft speed of 1500 to 3000 revolutions per minute.

BACKGROUND AND NEED: In general, torpedo prime movers, auxiliaries, and thrust producers operate at different speeds, necessitating the use of speed reducers and increasers. Since many underwater detection devices depend mainly upon noise, it is desirable that these power transmissions be as quiet as possible. Presently, precision gearing, sleeve bearings, dynamic isolation between gear meshes, accurate balancing, and vibration mounting are all used to minimize noise output. It would appear that other types of speed converters in which forces do not vary as a function of time are possible solutions to this problem and should be investigated. Examples of these are belt drives, roller drives, and cycloid drives.

PROBLEM NO. 8: Paint

Develop an economical paint or coating that would prevent sea growth on submerged objects during a 1 to 5 year period.

BACKGROUND AND NEED: Sea growth now limits the operational life of many Navy equipments, such as underwater sound sources, mine cables and cases, antisubmarine nets, channel buoys, and ship hulls. In the future it may be necessary to carry underwater missiles and torpedoes unprotected outside submarines. Sea growth on the control surfaces of these weapons would degrade their operation. Some means must be found to prevent or considerably reduce this growth.

PROBLEM NO. 9: Timing Device

Develop an accurate (±1 percent) short-period (5 minutes or less) rugged, inexpensive, highly reliable timing device having long shelf life capability.

BACKGROUND AND NEED: The mechanical timers available today do not store well and are adversely affected by vibration and temperature. Existing electronic timers have low reliability and are not stable enough to provide the required accuracy. The timer described above is needed for torpedo and underwater missile applications, such as safe-arming, range determination, and guidance mechanisms.

PROBLEM NO. 10: Transducers, Digital Output

Develop highly accurate digital output transducers. Development is needed in the area of transforming the variation of physical phenomena into a digital voltage with precision of one part in 2^8 to one part in 2^{10} with a frequency response from dc to several kilocycles.

BACKGROUND AND NEED: At the present time, transducers with a digital output are not available. The analog output signal of present transducers must be converted to digital form by circuitry external to the transducer before it can be used as an input to digital computers. Development might proceed along two lines:

a. Examination of materials for characteristics suitable for application to the transforming of physical phenomena into a digital voltage.

b. Refinement of analog instruments together with schemes of analog-to-digital conversion, perhaps in each end instrument.

Chapter 2

PROBLEMS IN ANTI-AIR WARFARE

PROBLEM NO. 11: Warhead

Develop a more effective fragmentation warhead (possibly by increasing the duration of the lethal fragment cloud optimizing fragment spatial distribution, or by modifying the lethal kill mechanism of the fragments).

BACKGROUND AND NEED: Currently, fragments are projected by explosions in one or more of the following ways:

a. Uncontrolled
b. Controlled
c. Rods, discontinuous and continuous
d. Shaped charges.

In head-on attacks against very high speed targets a warhead might project relatively slow fragments and utilize the target's speed for lethality. While there are existing warheads which project their fragments in a rapidly expanding spherical shell and thereby form a cloud, the cloud disperses rapidly due to the high fragment velocity. In addition, fragment spatial distribution is nonoptimum since target intercept probability increases as the center of an unbiased burst is approached while the number of fragments swept from a spherical shell decreases as the center is approached.

PROBLEM NO. 12: Warhead, Rod Type

Develop an inexpensive method to produce high quality continuous rod type missile warheads with a minimum number of possible variables in the manufacturing process and develop a satisfactory method of testing the rod assembly under laboratory conditions to simulate the loads experienced in explosive launching of the rods. The production method should eliminate as many of the presently used individual parts and joints as possible by incorporating new rod forming and manufacturing techniques.

BACKGROUND AND NEED: The present method of fabrication of continuous rod warheads uses individual rods whose length is approximately equal to the warhead. These rods are joined at the ends by deposition or resistance welding to form the cylindrical

PROBLEM NO. 12 (Cont)

rod bundle. This method produces a satisfactory rod bundle that will generally maintain continuity until fully expanded by the explosive charge. However, the production process is expensive and difficult to inspect.

With aircraft target speeds and skin toughness increasing steadily, the cutting action of the continuous rod warhead is expected to make this type of warhead more effective than the blast of fragmentation types in causing a high percentage of target kills.

PROBLEM NO. 13: Gyro, Inertial Reference

Develop inertial references for applications needing a shorter duration of reference than is presently considered in general usage. Emphasis should be placed on cost, size, weight, and reliability, and the accuracy (stability of reference) should cover the spectrum from a few degrees per minute to 10^{-4} degrees per hour.

A specific need exists for a simplified, inexpensive, spring wound course gyro, accurate enough to keep a torpedo on a rough course during snaky trajectory runs.

An additional area for improvement is in the time required for stabilization of a gyro after violent maneuvering by the aircraft. A vertical gyro with the same specifications as those in present use, but with a stabilization time of 3 seconds instead of the 9 to 15 seconds currently required would be satisfactory.

A lubricant with constant viscosity to be used in an environment of wide temperature and stress range as cited in the above applications is also needed.

BACKGROUND AND NEED: Emphasis in gyro development in the last decade has been toward high accuracy in a small package. The resulting complexity has lead to poor reliability and exorbitantly high costs, especially for small, low-cost missile applications. Two divergent trends for research and development are indicated:

a. An order of magnitude greater accuracy stability of reference would be needed in present size packages at no increase in cost to approach practicality for the small missile with conventional warhead.

PROBLEM NO. 13 (Cont)

b. Alternatively, for a spatial reference system of intermediate quality for use in conjunction with other guidance techniques such as homing devices, an order of magnitude decrease in accuracy would be reasonably allowable if the resulting gyro cost were to be reduced commensurately (e. g. , $300 to $500 total price objective).

An approach along the line of (b) above would be applicable to the torpedo gyro. Improved reliability at reasonable cost is desired for gyros in present use.

PROBLEM NO. 14: Switch, Low Energy

(Deleted)

PROBLEM NO. 15: Modulator, Infrared Fuze

Develop an electrical or magnetic modulator (shutter) for IR fuzes.

BACKGROUND AND NEED: Mechanical modulators are now used in this application, but they lack adequate reliability and it does not appear that they can be improved significantly. For this reason, electrically or magnetically operated modulators are needed. Any operating rate from a few cycles per second to a few megacycles per second would be acceptable, since the detector would be designed to match any modulator with acceptable reliability characteristics.

PROBLEM NO. 16: Stable Platform, Fixed Low Altitude

(Deleted)

PROBLEM NO. 17: Protection Thermal Techniques

(Deleted)

Chapter 3

PROBLEMS IN STRIKE WARFARE

PROBLEM NO. 18: Temperature Measuring Device

(Deleted) (Combined with No. 28)

PROBLEM NO. 19: Detonation System

Develop a simultaneous detonation system so that all warheads or groups of warheads, previously delivered inland by various means, may be exploded at a given instant to produce maximum effect on enemy troops. It should incorporate an antidisturbance provision that will cause each warhead to detonate in event of enemy tampering. Simultaneity could be achieved by a very accurate timing device, by command, or by mutual detonation through ground vibration. Separation into groups could be achieved by varying the fuze times, coded command signals or varying the times of arming.

BACKGROUND AND NEED: It frequently requires hours or even days to deliver adequate amounts of ordnance on enemy forces in entrenched positions in preparation for an assault, during which time the effect of initially delivered weapons has largely worn off. A system whereby the ordnance could be delivered within the capabilities of the offensive forces, yet simultaneously detonated in groups at critical times in the operation, would greatly increase the effect of the bombardment.

Such a system would require an arming device, a detonating device and an antidisturbance device to prevent disarming or removal by the enemy. The arming device could be time delay or command. The detonation device could be time delay, command or vibration. Antidisturbance devices would probably include a vibration sensitive element, however, other methods may be devised. Depending on the nature of these devices, the system could have multiple uses, including bombardment of troop concentrations and fortifications prior to assault, denial of specific areas, aircraft mining of restricted passages, interdiction of roads and railway lines, etc. For some of these, counting devices, as used in Naval mines, would be useful. Consideration should be given to the advantages of flexibility in operation, which usually adds complexity, and the consequent effect on reliability, possibility of enemy countermeasure and cost.

PROBLEM NO. 19 (Cont)

Present capabilities are based largely on contact fuzes or delay fuzes which are too variable to be effectively used in this manner. Adequate antidisturbance devices are not presently available.

PROBLEM NO. 20: Instrument, Boron Base HEF Analysis

(Deleted)

PROBLEM NO. 21: Treatment, Surface Protective

Develop economical surface treatments to protect ferrous and nonferrous materials from the heat and abrasive effects of missile booster blasts.

BACKGROUND AND NEED: The areas around shipboard missile launchers are now protected with heavy steel plate to resist booster blast forces. The deck plates and blast doors receive no protection other than standard paint, which requires renewal after missile firings. Plates are replaced depending on degree of erosion present. To date, stainless steel has been the most permanent material used, but it is subject to deposition buildup.

It is reasonable to assume that the development of a surface treatment to prevent erosion would permit the use of a lighter-weight resilient plate to absorb the pressure blast around the launching area.

PROBLEM NO. 22: Potentiometer, Feedback

Design a feedback potentiometer for use in the high temperature (1000°F) environments associated with missile servos.

BACKGROUND AND NEED: Potentiometers used in missile servo systems tend to break down due to environmental heating. As the temperatures increase, the resistance of the bridge changes, and inaccurate servo positions result. Also, the solder used in the potentiometer sometimes melts and increased temperatures cause mechanical binding.

Insulation against heat cannot usually be used because of critical space requirements. An insulating layer of two inches would be needed

PROBLEM NO. 22 (Cont)

for adequate protection; such a layer is in excess of allowable volume. Design engineers have suggested placing the potentiometer inside the hydraulic cylinder thus obtaining effective cooling from the hydraulic fluid.

To build a reliable feedback control circuit for high Mach missiles, high temperature feedback potentiometers must be developed.

PROBLEM NO. 23: Solid Propellants, Production

Develop equipment for continuous, accurate, and safe production of solid propellants. This equipment should include preparation of the oxidizer, accurate (±1 percent) feeding of solids into the mixer, homogeneous mixing and continuous in-process inspection to provide feedback information for regulation of input material. No more than 1 hour should be needed for testing the output propellant. This equipment must be capable of handling the most advanced solid propellant formulations.

BACKGROUND AND NEED: The amount of propellant used by newly designed large missiles has increased to the point that several batches of propellant are required for each missile.

With the advent of the high performance, high energy solid propellants, some concern has been expressed over the safety problems involved in mixing large batches of propellant. A continuous production process would provide large quantities with the advantage of having only small amounts of propellant in the dangerous mixing phase at any one time.

Many companies are working on design of equipment for continuous processing of one type of propellant or another; however, equipment is not being planned that can be adapted for processing all types of propellants. Equipment presently available is very expensive, usually needs modification to make it safe, and operates on the margin of the required accuracy. A reasonably priced solids feeder with an accuracy of ±1 percent is not available. Inspection methods and devices that can test the output propellant for proper formulation and uniformity within the short time available before the finished mix has to be poured also must be developed.

PROBLEM NO. 23 (Cont)

The successful solution of this problem would mean modernization of the solid propellant industry. It is expected that production capacity and flexibility would be increased while the greater uniformity of product would permit an increase in missile reliability and performance.

PROBLEM NO. 24: Servos, Pneumatic

(Deleted)

PROBLEM NO. 25: Nozzles, Variable, Free-Jet

Develop variable nozzles for free-jet applications.

BACKGROUND AND NEED: Many different nozzle designs have been used in free-jet applications. In free-jet subsonic flow, rectangular nozzles have been tried. For transonic flow, slotted and perforated nozzles have been used. A nozzle that performs efficiently in all regions is needed. The most promising approach appears to be a variable shape nozzle.

The information gleaned from free-jet tests using variable nozzles will be applied in the designing of high Mach vehicle nozzles.

PROBLEM NO. 26: Missiles, Loading Of

Develop a more rapid method of loading guided missiles on aircraft.

BACKGROUND AND NEED: An urgent need exists for development of a method for shipboard loading of guided missiles on aircraft that is more rapid than existing techniques. Current loading techniques for small missiles consist of utilizing either manpower or the MK VIII hoist. The advent of larger air-launched missiles in the fleet, such as BULLPUP 7B, and the KD2B target missiles, serves to highlight the limitations (time-wise) in currently used loading methods.

Recent developments in the field of shipboard mechanized handling equipment for transferring air-launched missiles from

PROBLEM NO. 26 (Cont)

stowage to the flight or hangar deck promise a great increase in missile delivery rates. While current developments of mechanized loaders for flight and hangar deck use indicate a partial solution of the aircraft loading problem for the larger missiles, these loaders will not be capable of meeting increased missile delivery rates which are now possible.

New methods and/or concepts for rapid missile loading of aircraft must be developed to improve our Navy's capability for mounting defensive or offensive aircraft strikes in the minimum possible time.

PROBLEM NO. 27: Control Systems, High Temperature Propellant Gas

Develop control systems for ultra-high temperature (3500°K).

BACKGROUND AND NEED: Solid propellant rocket engines could be made simpler and lighter if the propellant gases could be used to power all auxiliary equipment and for thrust vector control. The gases which are currently being generated in high impulse propellants are as hot as 3800°K; are corrosive due to chlorine, hydrogen chloride, oxygen, and carbon dioxide; and are particle-laden with liquid droplets of aluminum oxide. Future systems will reach higher temperatures, will be more c rrosive, due probably to the inclusion of fluorine in the propellant formulations, and may possibly contain higher temperature liquids such as zirconium oxide. The initial needs would be for valves, piping systems, or methods of cleaning the gases of undesirable particles. Possible methods for cooling the gases could be considered but for some requirements such as vectoring, it is advantageous to have the gases controlled at their elevated temperatures. Methods of controlling the gas flow without use of mechanical parts should be considered.

PROBLEM NO. 28: Temperature Measuring Device

Develop a means to measure the physical and thermal properties of the gas constituents of solid gas propellants together with an accurate temperature measuring system up to 8000°F.

BACKGROUND AND NEED: An accurate knowledge of the physical and thermal properties of propellant gases is fundamental to the calculation of aerodynamic performance, thermodynamic performance, and heat

PROBLEM NO. 28 (Cont)

transfer in rocket systems. Specifically, it is necessary to know the heat capacity, thermal conductivity, density, viscosity, diffusion coefficient, and emissivity of the particular gaseous species existing at a given temperature. A means for determining the temperature must also be found for temperatures in excess of 4500°F.

Several methods of estimating the properties of gases at elevated temperatures have been conceived based on intramolecular and intermolecular forces. However, in many of the areas, experimental data does not exist to confirm the property values predicted by the theory.

The temperature must be measured with an accuracy of ±50° at 8000°F. Test facilities presently use optical pyrometers and temperature probes with tungsten thermocouples. The optical pyrometers have not been found acceptable for this use and the probes are only useable up to 4500°F.

In general, methods employing physical contact with the stream of gases are unacceptable because of material limitations and disturbances introduced into the stream. Methods employing remote sensors such as sound velocity meters and optical and total radiation pyrometers are particularly applicable if the effect of boundary regions can be minimized.

PROBLEM NO. 29: Theory, Condensation and Nucleation Kinetics

Develop a quantitative theory of condensation and nucleation kinetics for condensation from the gas phase and support this theory with quantitative experimentation.

BACKGROUND AND NEED: A large number of present rocket propellants contain metal powders and thus yield significant quantities of a condensed gas in the exhaust stream. The kinetics of the formation of the condensed gas are important for a number of reasons. The velocity lag of the condensed particles as compared with the gas is a function of the particle size. Particle lag gives a loss of impulse. Knowledge of condensation and nucleation kinetics is important for predicting the particle size in the rocket exhaust and for guiding the design of nozzles to gain the most beneficial result. The particle size is also important for predicting the flow patterns within a rocket chamber. Condensation and nucleation processes are probably an important step in the combustion of metals.

PROBLEM NO. 29 (Cont)

A number of theories of condensation and nucleation kinetics have been presented, but the simplifying assumptions required make the results more qualititave than quantitative.

PROBLEM NO. 30: Sounding System, Meteorological

Develop a meteorological sounding system including a wind measuring capability for shipboard use. This system should have an essentially unlimited altitude capability and should not disclose the ship's position during conditions of maximum security and emission control. It should be capable of operating under all weather and sea conditions.

BACKGROUND AND NEED: Present sounding systems with acceptable altitude capabilities utilize radio telemetering to transmit meteorological data from balloon or rocket vehicles to a shipboard receiver. Winds are deduced by tracking active or passive radar targets. Such systems are not useable under emission control security conditions or when subject to enemy jamming action. A system using completely passive or indirect means of obtaining meteorological data for operational use is urgently needed. Preferably, the system should require no airborne vehicle. Electromagnetic radiation, if considered, must be highly directional and insensitive to jamming. Radiometric and/or spectrophotometric shipboard probes measuring absorption in selected light frequency bands, gas particle emission frequencies, scintillation caused by atmospheric effects, or sonic techniques may offer potentially productive areas of investigation.

PROBLEM NO. 31: Turbines, High Temperature

Develop turbines capable of operating at appreciably higher gas inlet temperatures than present designs (approximately 1800°F) with high efficiency and low noise. The turbines must be able to handle the solid reaction products resulting from the high energy combustion fuels that would be used.

BACKGROUND AND NEED: This is basically a materials problem. Until recently no materials were satisfactory for use at 1800°F. Materials such as inconel "X" have allowable stress limits of 8000 pounds per square inch at 1800°F. Materials having allowable stress of 30,000 to 40,000 pounds per square inch at 1800°F are now available.

PROBLEM NO. 31 (Cont)

The primary limitation of such alloys is their poor oxidation resistance. Since the use of high energy combustion fuels presents a situation where 10 to 15 percent of the work gases are solids such as metal oxides, the blades of the rotor must be of a material and design to overcome such limitations and use these combustion products efficiently.

Chapter 4

PROBLEMS IN SUPPORT EQUIPMENT

PROBLEM NO. 32: Inverters, High Ambient Temperature

Develop maintenance free inverters capable of operation in ambient temperatures up to 85°C. Units are desired for new applications and to replace existing inverters now in service that require high maintenance.

BACKGROUND AND NEED: Inverters now used in weapons systems are of the rotary type. The reliability of these units is low due to their many mechanical components: brushes, bearings, slip rings, commutators, carbon piles, and rotating frequency regulators. These components are continual sources of maintenance problems. With the recent strides made in semiconductors and electromagnetic materials, it is apparent that inverters which are virtually maintenance free can be designed.

Two families of ratings are required, ranging from 0.1 KVA to 4 KVA: one family of units with an output frequency of 400 cycles per second is needed for aircraft and a second family with an output frequency of 3200 cycles per second will be required for the support of missile systems.

PROBLEM NO. 33: Low-Pass Filter

Develop a low-pass filter which provides at least 60 decibels of insertion loss between a source and a load of any impedance over the frequency range of 10 kilocycles to 50 megacycles and that has no more than 1 decibel of insertion loss at frequencies between dc and 1 kilocycle. This filter should be operable with up to 100 volt dc, ac, or RF voltage inputs and with output current in the pass-band of up to 5 amperes. The filter should also be operable in environmental extremes of vibration, shock, temperature, pressure, and humidity. It should be packaged in a case no more than 1 inch in diameter and 3 inches long and should be relatively inexpensive in order to be used in expendable items.

BACKGROUND AND NEED: Presently available filters lack one or more of the required characteristics. Filters of the type specified above are required in Navy weapon systems to preclude hazards to

PROBLEM NO. 33 (Cont)

electrically initiated explosive devices from environmental electromagnetic fields. New developments in materials and construction will be required to achieve the necessary filters.

PROBLEM NO. 34: Searchlight, High Power

Develop a 50 million candlepower searchlight having an elliptical beam spread and a self-contained power supply.

BACKGROUND AND NEED: At the present time, visual contact remains the final means of finding a man in the sea. At night, lighting is required for this visual acquisition. Airborne search operations require the use of an airborne searchlight. These operations are carried out in slow speed fixed and rotary wing aircraft. At present, aircraft of this type must be specially modified to carry a searchlight.

The purpose of this problem is to develop a high intensity searchlight which may be externally attached to any fixed or rotary wing aircraft that is reasonably suitable for use in air-sea-rescue search operations. This searchlight would contain its own power supply and fuel. The only electric connection to the aircraft would be by wiring required to control the direction of light beam and to turn the unit on and off.

A searchlight beam of 50 million candlepower with 8 degrees horizontal by 3 degrees vertical spread and capable of one hour operation from self-contained fuel would be desirable.

PROBLEM NO. 35: Fire Detector and Fire Preventer, Rocket Motor

Develop high speed, fast response, ultra-violet cell to detect fire as an integral part of a fire-fighting system (. 070 second response time). Develop apparatus to prevent damage from spurious rocket motor fires in vessel magazines. This apparatus should use methods other than large quantities of water and should be capable of diverting the fire, thereby preventing ship damage and payload detonation.

BACKGROUND AND NEED: Present methods of preventing fire damage in magazines (other than conventional water flooding) include the use of foam agents for smothering oil type fires and the use of tubes for diverting rocket blast to the outside air. Since

PROBLEM NO. 35 (Cont)

solid rocket propellants need no external oxygen source for combustion, smothering methods retard propellant burning but do not completely extinguish the burning. For this reason other methods of venting gases and reducing the pressure within the rocket motor case, or rapidly cooling the propellant grain below its ignition temperature are needed. Direct water injection into the rocket chamber is presently used but required extensive pumping and distribution facilities. Water injection also requires a pump-out drainage system. The high density of stowage of rocket components in magazines and the limited space available to rockets stowed in "ready service" as complete rounds introduce severe size limitations on any proposed fire prevention method. The distribution and drainage system also imposes a weight penalty on the ship.

Fire safety in magazine and checkout areas is of prime importance on all Naval vessels. Also, it is conceivable that a fire prevention method developed for rocket motors that does not use large amounts of water would have application in other areas of a ship as well as in many land-based operations.

PROBLEM NO. 36: Instrument, Electromagnetic Warning

Develop a simple, reliable, inexpensive, lightweight instrument which will warn the carrier when he is in an area of electromagnetic energy of a power level of .010 watts per square centimeter or greater. The warning should be of the audible, sub-audible (vibratory) or thermal type, depending on the environment in which the instrument is to be used.

BACKGROUND AND NEED: Field-strength meters and other sophisticated devices exist which can detect the presence of electromagnetic energy. They are not, however, suitable to the application desired here. An instrument small enough to be worn without restricting the wearer's activity in any way is needed in order to solve the problem of preventing overexposure to electromagnetic radiation. Since the maximum permissible tolerance of a human being to different frequencies is not completely known, the instrument must respond to an extremely wide frequency band (10 kilocycles to 30 kilomegacycles), although the major area of interest will involve frequencies from about 500 megacycles to 15,000 megacycles.

PROBLEM NO. 36 (Cont)

The requirement for increased ranges and sensitivities of radar equipments have been approached, in part, by development and exploitation of greater power transmissions. At present, use of pulse power in the megawatt range is common. By 1965 use of even higher power is expected. Only limited exposure to these highly radiated power levels can be tolerated by the human body without damage to vital organs.

PROBLEM NO. 37: Fuel Tank, Explosion Hazard, Inertion

Develop an effective means of inerting the explosion hazard present in aircraft fuel tanks. The means used should operate continuously during flight and should add a minimum of weight and complexity to the airplane.

BACKGROUND AND NEED: An explosive mixture of fuel vapor and air is usually present in aircraft fuel tanks. This condition creates a potential fire and explosion hazard when sources of ignition are present. The hazard is aggravated in the case of low flying aircraft which are subjected to small arms ground fire and the attendant possibility of the bullet causing a spark in the fuel area. Inerting systems using stored inert gases or engine exhaust fumes have been attempted, but they have been too cumbersome or complicated to be practical.

PROBLEM NO. 38: Ice Formation, Fuel Systems

Develop a method or technique for overcoming or preventing the formation of ice in jet engine fuel systems.

BACKGROUND AND NEED: JP-5 fuel has an affinity for water. Numerous instances of low pressure fuel filter icing have occurred and two recent aircraft crashes were traced directly to fuel filter icing. Work should be done on fuel systems which have a minimum tendency to ice and on reliable, lightweight, low cost fuel heaters. Effort should also be made to reduce the contaminants that develop in JP-5 fuels.

PROBLEM NO. 39: Fuel Lines Couplings

Develop coupling devices for aircraft fuel lines that will insure fuel-tight connections after long periods of use under severe operating

PROBLEM NO. 39 (Cont)

conditions. Such devices should be easy to install in partially obstructed portions of the aircraft and should provide for ease of maintenance.

BACKGROUND AND NEED: Present fuel line couplings depend on compression of rubber to achieve adequate sealing. The rubber portion is frequently distorted or damaged due to misalignment, vibration, or swelling, and fuel leaks develop and create a fire hazard in the airplane. There is a need for a fuel coupling device that can (1) tolerate at least 6 degrees of misalignment, (2) permit a wide tolerance in attaching torque, and (3) remain unaffected by the high vibrations encountered in high performance aircraft.

PROBLEM NO. 40: Oils, Containers Turbine Non-Contaminating

Develop containers and cleaning procedures for containers which will assure hydraulic and turbine lubricating oils are free from contamination following storage.

BACKGROUND AND NEED: Malfunctions of hydraulic equipment and aircraft gas turbines have frequently been attributed to contaminated fluids, both of a petroleum and synthetic origin. Many of the contaminants found in oil systems appear to have originated at the oil producer, at the point of packaging, or are caused by a reaction product between the oil and its container. Development of a seam-sealing compound which is insoluble in these oils or, better still, the development of containers which do not require sealing compounds is desired. In addition, development of a cleaning procedure which will remove all contaminating solid particles and absorb liquids from the interior surfaces of containers to leave them clean to accept and prevent the contamination of extremely high purity oils is desired.

PROBLEM NO. 41: Fuel Filter, Reusable, Aircraft

Develop reuseable aircraft fuel filters that may be easily cleaned.

BACKGROUND AND NEED: Logistic reasons dictate the use of reuseable equipment wherever possible. It is known that filter elements made from metal wire cloth are more suitable for cleaning and reuse than paper elements. However, some reliable, repeatable method of cleaning out the very fine particles of trapped contaminant must be investigated and developed before they can be used.

PROBLEM NO. 42: Contaminants, Monitoring

Develop a device to monitor the amounts of contaminants (dirt, rust and water) in aircraft fuels.

BACKGROUND AND NEED: Current aircraft fuel systems are vulnerable to small amounts of contaminants which, because of the large quantities of fuel passing through the systems, accumulate in the delicate valves, orifices, gages, etc., and cause engine malfunction. All fuels handled in bulk tend to pick up contaminants. Even though these contaminants are controlled by the use of specially designed filter-separators, it is not easy to determine when a filter-separator malfunctions. If the malfunction continued undetected, serious engine problems can occur. Development work on stream monitoring devices has resulted in the detection of both dirt and water in the stream but accuracy is affected by the size and distribution of the contaminants. Although the devices respond differently to dirt and water, differentiation cannot be made between them.

There is an immediate requirement for a device which can be attached to the fuel system near the aircraft fueling hoses to continuously determine the amount of dirt and of water in the fuel stream in the range between 1 and 20 milligrams per liter. Preferably, the device should differentiate between water and solid particles. It should be designed to require a minimum of care and attention.

PROBLEM NO. 43: Meter, Fuel

Design fuel metering equipment which is insensitive to fuel-born dirt and ice.

BACKGROUND AND NEED: Long duration flights allow fuel to cool to the point at which dissolved water precipitates out and freezes into small ice particles. These ice particles, added to fine rust and sand particles in the fuel, clog present fuel metering equipment. Fuel metering devices which do not have moving parts in contact with the fuel would be less sensitive to such dirt and ice.

PROBLEM NO. 44: Fuel Leakage

(Deleted)

PROBLEM NO. 45: Fuel Control

Develop a simple, reliable, foolproof method of engine fuel control manipulation from the cockpit throttle lever position.

BACKGROUND AND NEED: Virtually every existing aircraft, and jet aircraft in particular, have been subjected to loss of engine throttle control due to various discrepancies in conventional power lever, pulley-cable, or push-pull rod actuation systems. Develop either:

a. A simple lightweight auxiliary method of engine control to be used in the event of normal control system failure or binding at any point from throttle level to fuel control, or

b. A completely new approach to engine control which would eliminate recurrence of past difficulties such as failed throttle levers, broken control rods, disconnected mechanical linkages (due to maintenance error or unreliable self-locking nut features) and binding or hang-up in the linkage system.

PROBLEM NO. 46: Switches, Toggle

a. Develop toggle operated switches compatible with the requirements of full pressure suit glove form factors.

b. Develop switches with handles of varying shape to permit easy visual identification and differentiation of circuits.

c. Develop switches compatible with the environmental requirements of full pressure suits.

BACKGROUND AND NEED: Toggle switches in use today have practically identical handles. When mounted in close proximity they are difficult to differentiate as well as to operate with a heavily gloved hand. The requirement that circuits be operable after explosive decompression of the cockpit establishes a need for environmental sealing of switching elements approaching the techniques used in hermetic sealing.

PROBLEM NO. 47: Stored Gas Pneumatic System

Develop a device for use in aircraft that will contain and burn multiple cartridges of clean burning solid propellant to provide high

PROBLEM NO. 47 (Cont)

pressure gas for inflight replenishment of stored gas pneumatic systems. Such a device would be used to maintain 3000 pounds per square inch system pressure. Each time that the system pressure would drop to a predetermined low pressure during flight, a cartridge would be burned and thus supply enough gas pressure to top-off the system.

BACKGROUND AND NEED: Present high pressure aircraft pneumatic systems employ air compressors to top-off the system in flight when the system pressure drops off. Explosions of moisture separators in these installations have caused aircraft accidents, resulting in loss of life, and extensive damage to aircraft. The explosions have been attributed to ignition of compressor lubricating oil in the moisture separator. Therefore, a substitute power unit to replace the air compressor, its driving unit (electric motor or hydraulic motor), moisture separator and chemical dryer would be desirable.

PROBLEM NO. 48: Turbojet Noise Suppression

Develop means to suppress turbojet engine noise.

BACKGROUND AND NEED: High intensity noise levels generated in the vicinity of jet aircraft by the present series of Naval turbojet engines pose serious hazards to both personnel and structures. The limited area of carrier flight decks and the proximity of continental Naval Air Station take-off and landing patterns to populated residential areas make it necessary to regard jet noise suppression as an urgent operational requirement. Work is now being conducted to determine the mechanism of noise generation in high temperature, high velocity jets. The ultimate goal is an inflight noise suppressor capable of 30 decibels sound pressure level attenuation with no appreciable attendant engine performance loss.

PROBLEM NO. 49: Compressor Stall Warning

Develop an instrument to sense and give warning of the approach of compressor stall in turboprop and turbojet engines.

BACKGROUND AND NEED: The acceleration rate of aircraft engines is limited by the factor that addition of more than a certain increment

PROBLEM NO. 49 (Cont)

of fuel flow will make the compressor stall. Present fuel controls compute the limiting value based upon the assumption that the engine will maintain constant characteristics. Engine characteristics are not identical from unit to unit of the same model, nor are one unit's characteristics constant with service life. If a parameter could be determined which consists of directly measurable quantities to indicate the approach of stall, many calibration and drift problems would be eliminated. The indication could then be used to manipulate some control device to prevent the occurrence of the stall.

PROBLEM NO. 50: Oil Measuring Device

Develop an oil quantity measuring device for use in Naval aircraft.

BACKGROUND AND NEED: A reliable method of indicating the oil quantity in "buried" oil tanks and constant speed drive reservoirs is needed. The device should be a piece of ground-installed equipment and should require no modifications to existing oil tanks. It should be adaptable to all MIL-L-7808 serviced aircraft and not require modification kits to meet this requirement.

PROBLEM NO. 51: Icing Condition Indicator

Develop an aircraft instrument for indicating the approach of icing conditions. Range of indication should extend up to the condition in which icing of the severest intensity is imminent. The instrument should, if possible, be powered with a self-contained battery supply. Indicators should be completely independent of variations in any specific atmospheric factor not directly contributing to the overall icing condition.

BACKGROUND AND NEED: Icing indicators currently used in aircraft are of the integrating type in which the pressure developed within a heated impact tube is compared with the pressure developed within an impact tube subject to icing. The latter tube is automatically and periodically de-iced when an ice coating forms. The frequency of the de-icing process is taken as a measure of intensity of icing conditions. These instruments are subject to excessive lag in indication and do not supply the warning signal until after the fact

PROBLEM NO. 51 (Cont)

rather than before. An icing indicator is needed which will furnish the signal sufficiently in advance of contact to permit the pilot to activate the anti-icing system.

PROBLEM NO. 52: Instrument, Transmissivity Measure

Develop a long path (at least 12,000 feet) instrument for the measurement of transmissivity of the air. Overall error should not be more than 100 feet in the first 2,500 feet and not more than 200 feet from 2,500 to 12,000 feet. If light is used with a wavelength in the visual range it must be pulsed at a rate to make it invisible to the human eye. Television techniques might provide a solution to the problem.

BACKGROUND AND NEED: Present equipment used for obtaining transmissivity or visibility operates over paths of 500 to 1000 feet. These short paths increase the calibration problem and necessitates the installation of complete duplicate systems where runways are on the order of 10,000 to 12,000 feet long. The long path system would reduce installation and equipment costs to a considerable degree and would also provide accurate information with less attention from operating personnel.

PROBLEM NO. 53: Lamp, Electroluminescent

Develop an electroluminescent lamp for use in aircraft control panels.

BACKGROUND AND NEED: Present control panels use red filtered incandescent lamps submerged in a lucite sheet as a light source. The placement of these lamps to achieve both uniform illumination and high reliability is critical. The use of electroluminescent lamps should provide:

a. A reduction in design problems since the lamp is a sheet having inherently uniform brightness. Also, there would be no socket interference with control placement.

b. A highly efficient light source resulting in low heat and ability to use miniature control elements.

PROBLEM NO. 53 (Cont)

c. No interference with dark adaptation in any aircraft with provisions for contact navigation or landing.

Problems requiring solution before electroluminescent panels can be employed widely include:

a. Means of making the electric connection.

b. Development of techniques to allow in-service modification or manufacture.

c. Increased surface brightness.

PROBLEM NO. 54: Meter, Field Strength

Develop a rugged, portable and extremely simple field strength meter for high level RF fields which will measure intensities from .01 to 1000 volts per meter with an accuracy of ±25 percent over the frequency range from 15 kilocycles to 15 kilomegacycles

A more immediate need is an instrumentation system for measuring the level of the electromagnetic energy which may be transferred from an aircraft on the deck of a carrier or on the ground to the ground plane (deck). The instrumentation system should be free from pick up effects and should yield consistent and repeatable readings in the frequency range of 250 kilocycles to 300 megacycles and at power levels from milliwatts to 100 watts.

BACKGROUND AND NEED: Field strength meters currently on the market are expensive, complicated, limited in their frequency response, and do not satisfy present needs. A simple, dependable instrument is needed which may utilize any basic principle. Current technology should be able to support such a development, although the frequency range requirement will demand an ingenious solution since it is coupled to practical use restrictions.

Field strength measurements are far from complete on present ships and Naval installations and they will be needed by designers and builders on all future construction. To effectively conduct research and development work on the correction of aircraft radiation hazards, it is necessary to accurately measure the magnitude of electromagnetic energy which may be transferred from the aircraft

PROBLEM NO. 54 (Cont)

to the ground plane as a result of parasitic excitation by adjacent RF transmitters. Available methods yield inconsistent and unreliable values because of probe pickup.

In addition, shipboard personnel should have their own meters. It is envisioned that weapons designers will be able to determine appropriate missile and launcher configurations as well as initiator energy requirements and limitations by referring to field strength and power density "maps". Thus, they will be able to predict the degree of hazard from electromagnetic radiation after the correlation of weapon aspect, configuration, frequency, field strength, and power density have been established.

PROBLEM NO. 55: Sensor, High Altitude

Develop a sensor for use in balloon-borne or rocket-borne equipment which will indicate the altitude of the bases and tops of clouds layers above the surface. This device will essentially measure the clarity of the atmosphere, but will discriminate between solid pollutants of the atmosphere and water vapor or particles. This device will measure cloud bases and tops within ±400 feet. Weight of total package should be less than 4 pounds.

BACKGROUND AND NEED: Optical backscatter and pulsed-light devices have been used, but these have been sensitive to solid particles as well as water particles, and lacked the capability of differentiating between them.

PROBLEM NO. 56: Presentation System, Atmospheric, Condition

Develop a system which will provide a comprehensive and continuous presentation of atmospheric conditions which affect the propagation or attenuation of electromagnetic energy.

BACKGROUND AND NEED: Atmospheric properties which affect propagation of electromagnetic energy in the lower levels of the atmosphere (surface to 15,000 feet) introduce serious problems in many operational areas. Present techniques for determining such effects rely on conventional meteorological soundings from ship, shore, or aircraft sources. The area coverage of these soundings is generally inadequate and the time interval between soundings is

PROBLEM NO. 56 (Cont)

not commensurate with the variability of the atmosphere. While a solution to this problem appears complex, a serious study may reveal practical techniques which could materially improve the present situation.

PROBLEM NO. 57: Sensor, Low Altitude Flight

Develop a common sensor capable of detecting essential parameters required for low altitude flight under conditions of reduced visibility.

BACKGROUND AND NEED: At present, aircraft contains various types of electromagnetic sensors to indicate parameters needed for flight control at low altitudes. They include radar altimeters, weather reconnaissance and mapping radars, doppler ground speed radars, terrain clearance radars, etc. There is a need for a single device which is capable of providing these parameters simultaneously. If at all possible, this device should be passive. It should produce accurate information on altitude, ground speed, terrain clearance, weather and obstacle avoidance, and other parameters now being obtained from separate installations. This device should be suitable for installation in a typical aircraft environment and should perform satisfactorily in any kind of weather in which it is possible to operate aircraft.

PROBLEM NO. 58: Altimeter, Precise

Develop new approaches to the problem of measuring the altitude of aircraft and the static pressures encountered at high altitudes.

BACKGROUND AND NEED: Airplanes and drones are now equipped with barometric altimeters and, in many cases, radar altimeters. The barometric altimeters become less accurate at high altitudes because the altitude pressure gradient decreases with increases in altitude. The situation becomes critical over 25,000 feet. In addition, the pitot static system furnishing static pressure to the altitude sensor suffers a degradation of accuracy as a function of aircraft speeds. In the transonic range (.95 to 1.05 Mach) the pressure registered is greater than the actual pressure. This is a serious problem in drones as they dive to make up for the apparent error. The problem is then further complicated by the fact that a

PROBLEM NO. 58 (Cont)

diving altitude increases the pressure error. The result is wild oscillation about the correct altitude.

Radar altimeters furnish information relative to the height of the airplane above terrain. This is not usually useful for altitude separation of aircraft because of the variation of terrain altitude.

It is considered, therefore, that a new approach is needed in the measurement of altitude to permit the separation of aircraft with a total system error of 250 feet or less at altitudes of 25, 000 feet and above.

PROBLEM NO. 59: Simulator Spin

(Deleted)

PROBLEM NO. 60: Physiological Monitoring

Develop a method for the continuous physiological and biochemical monitoring of pilot conditions during high altitude test flights to determine that he is mentally alert and capable of performing his duties. To meet this objective it is necessary to know the oxygen saturation of the blood, the percentage and partial pressure of oxygen in the inspired breath and/or the oxygen-carbon dioxide ratio of the expired breath. A further requirement is that the necessary measurements must be made without contributing to pilot discomfort or limiting pilot movement with attached instruments.

BACKGROUND AND NEED: Existing oxygen measuring systems have flow indicators to denote the flow of oxygen in the regulator. In 100 percent demand systems, where no flow indicator is used, a stoppage of oxygen is immediately recognized when the pilot is unable to inhale. There are recognized limitations to both of these warning systems and it is desired to develop a more positive type of warning. The oximeter and existing partial pressure indicators have been found to be acceptable laboratory instruments but a satisfactory aircraft instrument has not been developed. All possible means of detecting approaching hypoxia should be explored in order to evolve a system that will give the pilot advance warning of danger in order that he may take corrective action before loss of consciousness. An electronic method, which would give a continuous display of pilot blood pressure under test conditions, is a suggested approach to this problem.

PROBLEM NO. 61: Aircrew Containment Garment, Materials

Develop materials for a pilot containment garment which will eliminate the use of bulky straps and webbing and provide total containment for the body rather than the simple restraint provided by the conventional layered or combination belt types.

BACKGROUND AND NEED: Methods of restraint now used in aircraft have proved adequate for the lower acceleration forces but do not provide sufficient restraint at higher "g" forces and provide no containment of the man's vital organs. Also involved is the need for comfort which is not found in present restraint gear. The development of structural cloth would eliminate the thicknesses of webbing now required to accept excessive loading. Pneumatic exo-muscles should also be considered for restriction of aircrew arm and leg motion when under high "g" conditions.

PROBLEM NO. 62: Oxygen Utilization

Develop a highly efficient system for the utilization of oxygen that can meet the space and weight requirements of long duration flights.

BACKGROUND AND NEED: There is an urgent need to reduce the weight and volume required to store the large quantities of oxygen which are required for long duration flights of multiplace aircraft. The capabilities of some contemplated aircraft will require oxygen supplies ten times as large as are now used and it is anticipated that even greater amounts may be required in the future. Only preliminary investigations have been made in this area. Therefore, it is necessary that prototype installations be made and comparative evaluations conducted to determine their characteristics and adaptability to specific aircraft missions.

Some approaches which should be investigated are:

a. Regeneration of oxygen by such methods as separation of O_2 from exhaled CO_2.

b. Biological photosynthesis.

c. Scavenging oxygen from the rarified atmosphere.

PROBLEM NO. 63: Oxygen Breathing System, Chemical

Develop a chemical source of oxygen for aircrew breathing systems. This source should be compact, lightweight, capable of storage for long duration without loss due to temperature changes, easy to handle and stow aboard aircraft and available in increments necessary to meet the duration of an intended mission.

BACKGROUND AND NEED: In order to meet the need for increased oxygen durations, chemical oxygen sources have been investigated as a means of carbon dioxide absorption and oxygen generation. In a closed system it has been found possible to achieve a high degree of efficiency in oxygen consumption and thus achieve considerable savings in weight and storage space. In addition, chemical oxygen lends itself to efficient storage and transportation to the point of use, and is not subject to contamination or evaporation. Such a system was recently utilized in a six-day laboratory endurance test with satisfactory results. It is necessary that development be continued to produce a system for aircraft use.

PROBLEM NO. 64: Target, Visual Acquisition in Water

Develop equipment which will aid a searcher in an aircraft to visually acquire a target in the water.

BACKGROUND AND NEED: A target, such as a downed airman whose position is not accurately known, is very difficult to acquire visually if the contrast between the target and the background is marginal. Long visual dwell time is required, which results in spotty scanning during an aerial type search. Equipment which will direct the observer's eyes to a particular area for positive object identification is required to allow the search to proceed at a satisfactory pace.

The suggested method to be investigated in this problem is to use a photronic responder system (adaptation of photo cells) sensitive to contrast. This would be coupled with an automatic search device sensitive to the aircraft's direction and attitude to scan the maximum possible area. The man to be rescued would be expected to have clothing that would maximize his contrast against the sea. This development should emphasize high visual contrast for final location of target in the water. The detection system would be useful in both daylight and night search.

PROBLEM NO. 65: Rescue System Open Sea, Remotely Controlled

Develop an airborne open sea rescue system for personnel recovery that would be remotely controlled and would be capable of rescues during day or night under all weather conditions.

BACKGROUND AND NEED: A personnel recovery rescue system that could be remotely controlled from a carrier or cruiser to pick up and transport downed aviators would have decided advantages over the present system of employing manned helicopters for effecting rescues. The system should be capable of reaching a person or persons in the water and effecting a rescue whether or not the victims are capable of helping themselves. It should be capable of rescues at night under all weather conditions at distances beyond helicopter range, and should be designed to cope with the most difficult retrieval problems.

PROBLEM NO. 66: Aerial Recovery, Improved

Develop methods of aerial recovery which provide the same function as the standard parachute but which are not subject to failures at high speeds and altitudes and which offer no incumbrance after touchdown.

BACKGROUND AND NEED: The standard cloth personnel parachute is subject to material failure when deployed above approximately 300 knots at sea level. The speed at which damage occurs decreases at higher altitudes, thus restricting parachute opening to 10,000 feet or below. After landing, the parachute canopy and suspension lines become a liability, particularly in the presence of moderate to high surface winds wherein dragging occurs and can be fatal either on land or water. In a zero surface wind condition, the man is subject to entanglement in the suspension lines and drowning may result. By going to other means of recovery (rotor blades, retrorockets, etc.) the disadvantage of the cloth parachute can be overcome and a steerable descent and controlled touchdown may conceivably be provided.

PROBLEM NO. 67: Photosensitive Materials, Dry

Develop dry process photosensitive materials.

BACKGROUND AND NEED: Present dry process papers fade out when exposed to light and are not reproducible. A reproducible

PROBLEM NO. 67 (Cont)

direct print-out paper would have application in an optical galvanometer where it would have to be capable of moving at a variable speed of up to 170 inches per second past the image area. A second application would use film of this type in a cathode ray oscilloscope requiring the film to operate at a maximum speed of 380 inches per second.

A material of this nature would have wide application in airborne camera work. Present materials utilizing chemical developers contribute materially to the time delay between acquisition and availability of the photographic reconnaissance for utilization. The urgent need to appreciably shorten the interpretation cycle requires that the image be available for analysis after only a minimum time delay, or that the image be available for immediate scan and transmittal to base. This requires the development of photographic materials that are susceptible to high speed dry development or that requires no post-treatment for producing a visual image.

Considerable study, research, and development effort at this time is being directed toward dry photographic systems, near-dry airborne processing systems, and electrostatic systems. These systems show some potential and future effort should be directed toward improving these systems to a useable state. The dry photographic systems and electrostatic systems need vast improvement in response and sensitivity and the near-dry airborne processing systems need considerable improvement in quality and reliability.

PROBLEM NO. 68: Cockpit Enclosures, Transparent

Develop methods of fabricating transparent cockpit enclosures of composites comprising a load bearing ply of stretched acrylic plastic protected by a transparent thermal barrier.

BACKGROUND AND NEED: The best of available plastic cockpit enclosure materials, when used monolithically, are limited to skin temperatures of about 250°F. Inorganic glass entails severe weight penalties and a sacrifice in vision. In the absence of more thermally stable, structurally efficient transparent resins, composites as described above offer the best compromise for service from 250°F to 400°F, and ultimately perhaps 500°F.

Chapter 5

PROBLEMS IN SUPPORTING RESEARCH

PROBLEM NO. 69: Aerodynamic Forces On Bodies In Motion

Develop practical, analytical and experimental methods for the determination of aerodynamic forces on bodies in any state of motion.

BACKGROUND AND NEED: Structural design for missiles involves the use of aerodynamic forces which cannot be computed exactly. Small differences in damping, center of pressure, etc., have significant aeroelastic effects, and a combined analytical and empirical approach is necessary. Use of static wind tunnel model tests to establish oscillatory aerodynamics coefficients is a useful tool. However, new mathematical approaches are needed to develop aerodynamic data on wings of finite thickness, and low aspect ratio undergoing arbitrary displacements at any Mach number up to 10. More measurements are likewise needed to confirm significant features of the new theories as they are created.

PROBLEM NO. 70: Microminiaturization

Continue research and development in microminiaturization.

BACKGROUND AND NEED: Vast amounts of work are being done in this field, especially in electronic components and subassemblies. Typical is the recently developed evaporative film technique.

While the size of transistors has been steadily reducing, the semiconductor must be encased to prevent contamination. A technique for preventing contamination without utilizing a case would permit the size reduction trend to continue.

Continued work has resulted in achievements in many fields of miniaturization including: (1) etched wiring, (2) printed components, (3) photolithographic fabrication of diodes and transistors which become integral parts of printed circuits, and (4) miniaturization of power supplies, mechanical parts, and antennae. Further development is needed for several items including: (1) interconnection of microminiature subassemblies and diodes, (2) protective coating for caseless transistors and diodes, (3) dip-soldering techniques for microminiature etched wiring boards, (4) hermetic sealing of total assemblies, (5) reduction in size of several types of power supplies, electromechanical devices and transducers, and (6) RF cables with regard to ease of

PROBLEM NO. 70 (Cont)

assembly, ruggedness, and ease of testing for assuring correct assembly. Areas which require further study, if microelectronic systems are to become practical are: (1) radiation damage, (2) thermal problems, and (3) vibration problems.

Microminiaturization research and development must be continued because of the obvious space and weight saving factors which will result and the potentially large improvement in reliability which may result.

PROBLEM NO. 71: Vacuum Tube

(Deleted)

PROBLEM NO. 72: Electrical and Electronic Components, Improvement

Many problems exist that may be classified as "Improve the reliability of standard electrical and electronic components". Such components as resistors, capacitors, connectors, and switches fall into this category. Some specific problems in this area are outlined below.

a. Transistors. Develop a high volume production technique for transistors which will assume that 99 percent of the product, as a minimum, have performance characteristics which conform to design goals.

b. High Temperatures and Pressures. Develop electrical and electronic components capable of operation at temperatures from -40°F to 500°F and pressures from near zero pounds per square inch to 2000 pounds per square inch. Their operating characteristics must be accurately predictable within these ranges. Specifically, a new type of resistor should be developed to replace the composition resistor. This new resistor should have low noise characteristics as well as have stability that is not obtainable with composition resistors. Another desirable development would be a more reliable method of printed wiring.

c. Capacitors. Develop large value electrolytic capacitors (50 to 100 microfarads) that have less than 5 microamperes leakage with rated voltage applied at 165°F.

PROBLEM NO. 72 (Cont)

d. Uniform Characteristics. Produce components that exhibit uniform characteristics among lots and between manufacturers.

e. Connector. Design a totally new type of electrical connector that would have significantly higher reliability than that exhibited by current connectors. This design might take the form of a connector configuration that permits 2 leads to be joined directly, instead of the present connector configuration that requires the leads to be joined to pins that are then placed in contact. This improvement could reduce the sources of failures due to open circuits by a factor of 3 to 1. The ability to disconnect and reconnect easily and realiably must, of course, be maintained.

f. High Pressure Connectors. Develop pressure-tight electrical connectors that can withstand hydrostatic pressures of 5000 pounds per square inch.

g. Silicon Transistors, Cost Of. Reduce the cost of silicon transistors to the level of present day germanium transistors. Silicon transistors are desirable for shipboard and missile use because they are comparatively rugged; however, their present high cost tends to limit their use.

h. Terminals, High Temperature. Develop terminals suitable for use on high temperature wire operating at 650^{o}F and for use on thermocouple wire of various materials. These terminals are to be capable of being crimped by the same tool, but need not be identical in design for the various applications. While pre-insulation is desired, post-insulation would be acceptable.

i. Sockets, Improved. Develop improved sockets for "plug in" components. Transistor, diode, capacitor, and resistor clips are often responsible for component failure. Improved mounting methods are needed.

j. Inductive Spikes. Develop built-in provisions for the suppression of inductive spikes in all components that are sensitive to inductive loading. In particular, contacts of miniature relays, switches, commutating devices, and transistorized power supply elements are often subject to transients which seriously impair their operating life. An alternative, but less desirable, solution to this problem would be to dissipate or bypass inductive spikes.

PROBLEM NO. 72 (Cont)

k. Printed Circuit Techniques. Improve the reliability in current printed circuit techniques through better materials and component insertion provisions, and more efficient handling and repair provisions.

l. Components with Controller Failure Modes. Develop standard electronic components (electron tubes, transistors, etc.) with controlled failure modes.

m. Preventive Maintenance. Develop components which give indication of certain phases of incipient failure for equipments that are subject to preventive maintenance programs. The indication would be provided by a change in appearance of the component or even remotely indicated through a switch action or an extra set of contacts. Such components could provide a marked improvement in the performance of systems in which the critical parameter is not the total maintenance requirement, but rather the availability of the system during demand periods.

n. Tubes, RF High Power. Develop high power RF tubes, such as klystrons, magnetrons, pulse modulators, etc., which are relatively insensitive to the sequence of voltage and power applications used to initiate operation.

o. AC Operated Relays. Develop a family of ac operated relays. These relays are to operate with alternating current having the characteristics described in MIL-STD-704, and to be suitable for 120°C operation at 70,000 feet.

p. Develop small, low inductance capacitors rated for at least 1 microfarad at 4 microfarads at 2500 volts dc working voltage. Reliability must be at least equal to present large capacitors of similar specifications.

q. Develop a reliable 500 farad capacitor; 75 volts dc, working voltage; with a maximum size of 1/2 inch by 1/4 inch by 3 inches.

r. Provide information on resistance to nuclear radiation for all components.

s. Develop a high RF environment cable connector with good shielding characteristics.

t. Develop transistors with stable operating temperature characteristics.

PROBLEM NO. 72 (Cont)

u. Develop transistors that are immune to storage temperatures of from -80°F to 160°F.

v. Develop a transistor capable of operating at 200 megacycles at a power level of 2 watts.

BACKGROUND AND NEED: (Letter designations in this section correspond to letter designations in the problem statement.)

Present components are designed for inexpensive quantity production. Few, if any, are produced with repeatable, accurately defined, small tolerance characteristics.

a. Present volume production techniques applicable to vhf transistors yield a high percentage of products which fail to conform to design parameters. As a consequence, selective screening of the product is necessary. This contributes to inordinately high costs and low production rates as compared with similarly rated vacuum tubes or with transistors with less stringent operating conditions. Designers are not able to use the best transistors because of short supply. As an example, production of 2N239A transistors is far lower than the need while production of 2N237A and 2N238A transistors is more than adequate. These latter transistors do not meet the temperature requirements specified for the 2N239A.

b. Electrical wire has been developed that withstands temperature in excess of 1000°F for short periods. This is a result of insulation improvements rather than superior wire materials. RF conductors have been investigated without too much success. As far as other electric and electronic components are concerned, some superior components are being developed for operation under conditions that approach those given in the problem statement. Improved insulation methods and cooling techniques for electronic packages are not considered to be desirable solutions to this problem since they increase system weight and power requirements.

e. Present connectors do not stand up under extreme environmental conditions and space limitations prevent increases in reliability by increasing size. They are subject to contagious maintenance in that repair of one failure leads to others. Presently used military connectors require solder attachment of wires to contact. The high degree of success attained with crimp type terminals over formerly

used solder terminals indicates that a similar degree of success might be achievable if the technique were applied to connector contacts. No known work is being done toward the development of a radically different connector such as that described in the problem statement.

f. Pressure-tight electrical connectors, as described, do not exist at present. However, they must be developed so that future externally carried submarine weapons may be linked to controls with the submarine.

g. Developments are well underway by the Air Force to mass produce high power (2, 5, and 15 ampere, 120 volts) silicon transistors. This will result in the availability of equipments such as high output inverters. This will also produce increased ruggedness and reliability in static relays, servo-amplifiers and other associated equipments. The use of electronic devices in ordnance equipment has shown an exponential growth during the past decade. Future design goals of such devices (with respect to physical size, reliability, initial cost, and related criteria) have made it obvious that component improvement must be exploited to the maximum practicable extent.

h. High temperatures are occurring in ever-increasing applications. Present MIL-T-7982 terminals are limited to 105°C if pre-insulated and 200°C if post-insulated. The materials are not compatible with the application and severe flaking of the plating has been experienced. Terminals for application to thermocouple wire and for use above 200°C are applied with high temperature solder, requiring a high degree of skill in making the union. Inspection of such a joint is difficult and does not provide a satisfactory degree of assurance. Materials for the terminals and for plated surfaces must be thoroughly investigated and carefully chosen so that failures normally associated with dissimilar metals in contact will not occur.

l. The use of redundancy techniques to improve system reliability is widespread. Frequently, such techniques involve parallel circuit configurations which permit survival if a component fails "open", but not if it fails by short circuiting. It is possible to incorporate fusing action within a component which converts an internal short circuit to an "open". In this manner, the probability of a prolonged short circuit is greatly reduced, at the sacrifice of increased probability of an "open". Although the overall failure rate of the component may

remain the same, the probability of circuit failure may be greatly reduced when a parallel circuit configuration is employed.

m. Some work has been done along these lines; a tube is now available which glows with a particular color when approaching emission exhaustion. In reality, a wide variety of forms of degradation could be made to reveal themselves -- partial loss of vacuum, subjection to damaging environment, and various forms of mechanical wearout, depletion, etc.

n. Currently available RF power tubes are giving short life in service use, principally because of their susceptibility to internal damage when they are brought from the "standby" to the "radiate" condition. Although equipments are provided with elaborate interlocks and complex procedures for "coming up to power", the tube's susceptibility to damage remains a serious failure accelerating factor.

o. Except for a few special, low power applications, relays for operation from the weapon ac system require a rectifier. These rectifiers are severely limited as to temperature application and reliability. Applying alternating current to the coil causes heating and chatter resulting in wear of the mechanical structure. The noise level of power contactors, with 400 cycle alternating current applied to the coil is such that the relays must be muffled or located in other than inhabited areas. The availability of ac coil relays will permit control directly from the ac power line without intermediate conversion.

p. The main problem here is size. An existing capacitor meets the requirement but its size (1 inch diameter by 4 inch length) is much too large for the intended use with exploding bridge wire initiator as a fuzing power source in missile fuzes.

q. This capacitor would find application in production of Naval ordnance. The tantalum capacitors that are grouped together to fit the size requirement are not reliable and will not handle the required working voltage.

r. Industry has not provided sufficient information on the parameters. Many components that may have adequate resistance to nuclear radiation are not being used because there is no information available for evaluation.

PROBLEM NO. 72 (Cont)

s. Most cable connectors currently in use are made of aluminum. This material is poor in regard to RF shielding.

t. Many direct current equipments have drift problems because transistors used in their construction are not temperature stable and are subjected to small temperature differences. The present approach is to keep the environment constant and equal on all circuit elements, which increases the bulk and the power required to operate the equipment.

PROBLEM NO. 73: Structural Effects, Shock, Vibration And Acoustic

Develop analytical and experimental methods for the determination of shock, vibration, and acoustical effects on unheated and heated, non-linear structures.

BACKGROUND AND NEED: Since the inputs to structures are statistical in nature, it is difficult to predict the response and failure rate of the basic structure or for any electronic equipment mounted on the structure. A large amount of judgment is necessary for structural design. New rational approaches to this problem are necessary. Tests of design judgment need to be devised for conditions similar to those in practice, and economical enough that a large amount of data can be acquired.

PROBLEM NO. 74: Analog-to-Digital Converter

(Deleted)

PROBLEM NO. 75: Computer Specialized

(Deleted)

PROBLEM NO. 76: Memory Medium, Erasable

Develop an erasable mass memory medium for digital computers which can provide information transfer rates on the order of 50 million bits per second with random or semi-random access, with access time shorter than that for large drums or discs.

PROBLEM NO. 76: Cont)

BACKGROUND AND NEED: In large computer systems there is a general need for memory capacity for storing large quantities of data, partly processed values, and utility routines. Until recently, this need was best met by magnetic tapes, which have the disadvantages of low transfer rates and long access time to random locations. Large magnetic drums and discs now available have better characteristics in both respects than magnetic tapes, but still require access times which are long in terms of computer operations; the cost is rather high if very high transfer rates are provided.

PROBLEM NO. 77: Digital Signals, Oral or Handwritten

(Deleted)

PROBLEM NO. 78: Memory Computer

(Deleted)

PROBLEM NO. 79: Heaters, For Testing Air Breathing Engines

Develop the following types of heaters:

a. A heater to deliver high temperature, high-pressure air for testing hypersonic air breathing engines. Heater should have the following characteristics:

(1) Air enthalpy range: 2500 BTU/lb to 16,000 BTU/lb
(2) Pressure range: 2500 psi to the highest attainable
(3) Mass air flow: 3 lb/sec at 2500 psi, M10, less at higher M
(4) Testing period: up to 10 seconds

b. A heater with a capacity of 500 British Thermal Units per square foot per second for combined environmental testing (centrifuge mounting).

BACKGROUND AND NEED: (Letter designations in this section correspond to letter designations in the problem statement.)

PROBLEM NO. 79 (Cont)

a. Electric arc heaters now under development are expected to culminate in an air heater capable of operating at a pressure of 2500 pounds per square inch with 15 megawatts power across the arc, and provide correct simulation of free flight conditions up to Mach 10.

The heater described in the problem statement is needed for testing air breathing engines under correctly simulated hypersonic conditions above Mach 10 and up to orbital speeds. This heater has additional applications in hypersonic wind tunnel testing. The heater should ultimately be developed to provide the highest temperatures, pressures, and mass flows attainable. Capabilities intermediate between the ultimate and those now considered attainable are of interest and would be useful as soon as developed.

Failure to solve this problem will necessitate development of propulsion systems by flight testing which is extremely expensive both in manpower and resources.

b. The simulation of aerodynamic heating requires a well controlled high heat. Quartz heat lamps are well controlled but have too low a heat output. Luminous flame produces more heat but the control is not accurate enough for the desired application. The heater desired would greatly increase the state-of-the-art. Such a heater might be used as the heat source for the unit described in part (a) of this problem.

PROBLEM NO. 80: Cryogenic Units

(Deleted)

PROBLEM NO. 81: Camera, High Speed

Develop a high speed camera with a maximum frame rate of 100,000 to 1,000,000 frames per second that is compact, reliable, rugged, easily synchronized and possesses an exposure time of 1/10 of a microsecond or less and a capacity of 100 or more frames per event.

BACKGROUND AND NEED: A better understanding of many ultra-high speed phenomena (e.g., chemical explosions, high speed jets) depends on being able to view the phenomenon and evaluate its

PROBLEM NO. 81 (Cont)

characteristics. A camera which fills the gap between compact, moderate price, rotating-prism moving-film cameras and bulky, expensive, rotating-mirror, fixed-film cameras would answer a real need. It could be used in much the same way as the rotating-prism camera but for events occurring at much higher speeds. For example, the period of greatest interest in the detonation of an explosive device can be seen presently only on several frames, unless the bulky and expensive mirror cameras are used.

PROBLEM NO. 82: Inspection of Welds, Propellants, Motors, Laminates

Develop a rapid simple and nondestructive means for inspecting quality of:

a. Welds
b. Solid propellants and explosive loads
c. Large solid propellant rocket motors
d. Welds in laminates.

BACKGROUND AND NEED: Inspection of metals with specific reference to welds has been approached by means of ultrasonics, magnetics, fluorescent phenomena, and radiographic inspection. These methods require either relatively complex equipment, highly skilled interpretive ability or a combination of both. In addition, experience in using these methods for weld inspection has generated suspicion concerning judgment reproducibility.

Solid propellant grains and explosive loads are presently subject to ultrasonic and radiographic inspection. Both techniques require interpretative skill of the equipment operator, and the latter is costly and hazardous if improperly employed.

Inspection of large diameter, large grain solid fuel rockets is not adequate due to the fact that no means exists for inspection for all types of defects. The best accuracy obtainable in detecting flaws is limited to a significant percentage of the thickness of the material being inspected. Equipment now used for inspecting large grain solid fuel rockets include X-rays of energy levels of approximately 30 million electron volts, ultrasonic units and radioactive tracer techniques. Quality control methods have been standardized for inspection of large batches of small size solid propellants. Now that propellant size has increased, no inspection method assures

PROBLEM NO. 82 (Cont)

homogeneity from sample to sample. The incorporation of radioactive isotopes into the propellant mixture aids in inspection for homogeneity. Ultrasonic methods are used for checking case bonding. Bore-scopes are employed (visual inspection) when the propellant is cast with a hole in it. Voids or discontinuities as small as 1 inch by 1 inch by 0.010 inch must be detected. Areas where propellant materials contact the case without bonding must be found.

Laminated structural materials have presented a special problem. Ultrasonic inspection for laminar defects in metals is relatively simple. However, in non-metallic substances, each individual case represents a complex problem.

PROBLEM NO. 83: X-Ray, Flash

Develop a 1 to 3-megavolt flash X-ray device with an extremely rugged or expendable X-ray source of small size. The device should provide from 2 to 10 flashes of 0.1 to 1 microsecond duration in an arbitrary, but accurately timed, sequence with a delay between flashes in the order of 25 to 1000 microseconds.

BACKGROUND AND NEED: This device is needed in research on explosive effects and other high speed phenomena. Small units are available with short duration and low penetrating power. More powerful units have been built with as many as 3 channels in controlled sequence and separate tubes operating at 300 to 600 kilovolts and 0.1 to 1 microsecond. Present practice uses condenser or line discharges, with or without a pulse transformer, to provide arc or field emission discharge through a specially designed tube. The design of the device is believed to be within the realm of current technology.

Flash X-ray devices are needed to view solid materials in the presence of the smoke and flash accompanying an explosion or during penetration. Higher power bursts of hard X-rays are required to penetrate the materials used to protect the film from the blast of the explosives. The device would be particularly useful in the study of important explosive phenomena, such as the motion of solid materials in exploding warheads, the penetration of hypervelocity projectiles, or the burning of rocket propellant grain inside a motor tube.

PROBLEM NO. 84: Test for Bond Strength, Nondestructive

Develop a nondestructive test method to measure bond strength between similar or dissimilar materials.

BACKGROUND AND NEED: Present test methods are limited to ultrasonic and radiographic techniques. When used with solid propellant rockets, the test results give only a relative index of the presence of a bond. They are of no use in determining the degree of the bond.

It is essential that a definitive nondestructive test method for bond strength between similar and dissimilar materials be available in order that the producers of solid propellant rockets (as well as other products) can give assurance of acceptable performance.

PROBLEM NO. 85: Test, Mechanical Relative Efficiency of Laminate Bond

Develop a mechanical test to measure the relative strength of the bond between all layers of laminated plastic (or other) materials.

BACKGROUND AND NEED: There are no adequate empirical tests that evaluate laminar strength of materials. Not only is it necessary to have a method for measuring relative laminar strength but it is also necessary that the test results be in numerical form.

A test method, as described above, will make possible effective control of processing variables to create laminar structures of optimum strength. The safety and performance limits of solid propellant rockets could be extended, for example, by evaluation of the laminated materials.

PROBLEM NO. 86: Inspection Method, Solid Propellant Chamber

Develop a nondestructive inspection method for evaluation of the quality of bond between a solid propellant chamber liner and the propellant mass.

BACKGROUND AND NEED: Current methods for the inspection of the bond quality between a solid propellant chamber liner and the solid propellant are limited in effectiveness. For metal chamber materials, limited succes has been achieved with ultrasonic techniques. Although actual separation can be detected, no accurate

PROBLEM NO. 86 (Cont)

measure can be made of the quality of the bond at the interface of both materials. Conventional ultrasonic techniques do not work with nonmetallic chamber materials.

A nondestructive inspection system capable of detecting flaws and evaluating a bond with all chamber materials would permit quality limits to be established for the interface bond and guarantee acceptability prior to use. This would contribute to the development of materials of maximum reliability and make possible quality evaluation during production.

PROBLEM NO. 87: Transducers, Digital Output, Test Stands

Develop transducers for use in programs such as on rocket engine test stands that have digital rather than analog output. The digital output should be of binary form and not a method employing frequency modulation.

BACKGROUND AND NEED: Considerable development work has been expended in the field of analog-to-digital conversion but to date transducer manufacturers have not incorporated this as an integral characteristic of the transducer. The conversion equipment or device should be small enough so that it will not interfere with other test stand instruments.

The analog output signal from a transducer is usually very low in power and susceptible to amplitude error pickup. A digital signal of equally low power is not nearly so error-prone since "yes or no" rather than "how much" information is being transmitted. Digital transducers would find wide useage in testing and would be particularly beneficial in applications where on-line or real-time computers are used for data processing.

PROBLEM NO. 88: Moisture Determination in Solid Propellants

(Deleted)

PROBLEM NO. 89: Nitrocellulose, Determination in Solid Propellants

(Deleted)

PROBLEM NO. 90: Quantitative Studies Correlative of Temperature vs Chemical Reaction

Conduct quantitative correlation studies of temperature vs chemical reactions occurring in solid propellants due to aging.

BACKGROUND AND NEED: The state-of-the-art includes a method for determining the relative stability of freshly manufactured solid propellants but it does not predict what the apparent stability of such propellants would be after extended periods of storage under specified conditions.

Such a development would make possible the prediction of the shelf life of solid propellants insofar as the safety and performance of the solid propellants are concerned. In addition, a development of this nature would make the screening of propellant compositions possible, eliminating those that are not worthy of further development because of their poor storage characteristics. Such a test would allow accurate field life estimates which, in turn, would improve logistics insofar as the return of rockets for replacement or rework is concerned.

The return of units from the fleet to a manufacturing facility is undoubtedly a source of valuable information in regard to aging characteristics. However, if records of the various conditions which might affect a propellant such as mass effect, temperature, humidity, position of storage, etc., were maintained and transmitted to the manufacturing facility along with the rounds, such information would be of greater value. It would also be desirable if, in addition to the external conditions, the temperature and humidity within the unit could be checked and recorded.

Determination of the residual stabilizer and the acidity developed during storage would permit firmer predictions about safe storage life, with consequent elimination of defective material without destructive testing.

PROBLEM NO. 91: Metal Coated Glass Fiber Tensile Strength

Study the problem of retaining tensile strength in structural materials in the temperature range of 1500° to 2000°F through the use of metal coated glass fibers.

PROBLEM NO. 91 (Cont)

BACKGROUND AND NEED: In the field of structural materials, present and past emphasis has been placed upon raising their tensile strength; little effort has been expended toward increasing their stiffness. Although it is known that the modulus of elasticity is a difficult property to alter appreciably by alloying, the stiffness of structures is becoming so improtant that materials with higher modulus of elasticity to density ratios must be developed. Much work is being done on higher melting points and higher modulus filaments, such as quartz and other fibrous materials. Effort should be directed toward combining these fibers with a metallic matrix, such as the glass fiber reinforced aluminum materials developed by Owens-Corning. The glass fibers supply high strength and stiffness properties while the metal provides a high temperature bond. However, this particular material does not solve the problem stated above.

New materials capable of withstanding higher temperatures and greater stresses must be developed so that further progress in airframe development will not be limited by structural deficiencies.

The problem is broader than that of retaining tensile strength and should include development of new materials such as metal coated fiber glass, that have superior qualities at high temperature. Properties such as bending strength or manufacturing complexity are often as important as tensile strength.

PROBLEM NO. 92: Materials, Structural, Deformation of Materials

(Deleted)

PROBLEM NO. 93: Hydraulic Fluids, Coatings and Seals

Develop the following for use with either petroleum base or phosphate ester base hydraulic fluids:

a. A protective coating that is chemically inert to contact with the above fluids.

b. Compatible seals or seal materials.

PROBLEM NO. 93 (Cont)

c. A preservative that can be added to these fluids that will not adversely affect the properties of the fluid and will prevent corrosion of the hydraulic system over a long term period.

BACKGROUND AND NEED: Hydraulic power transmission systems, hydraulic mechanisms, and their associated controls are used extensively in Naval weapons in the elevation and train mechanisms of turrets, gun mounts, gun directors, missile guidance and launching systems, and ordnance handling equipment.

Power transmission fluids have a tendency to leak through small openings. At present, rubber seals are the best method to prevent such leakage. Since aromatic compounds in the hydraulic fluid injure some kinds of rubber, the quantity of aromatics must be controlled by formulation of the fluid from base stocks with minimum aniline points. However, a hydraulic fluid with the desired properties can not always be obtained. In addition, to minimize injurious effects, packings and other nonmetallic components of hydraulic systems should be made of some oil-resistant material. Current hydraulic fluids contain additives to improve their performance in the system, but these have not been completely satisfactory. Additives should be nontoxic and have nontoxic partial oxidation products.

PROBLEM NO. 94: Materials, Intermetallic And Glass Combinations

Develop materials such as intermetallic and glass combinations having higher strength to weight ratios and higher modulus of elasticity to density ratios at elevated temperatures.

BACKGROUND AND NEED: At present, missile airframes bend and deflect without approaching their ultimate yield strength. However, this bending affects control considerably since the aerodynamic flow is altered. Designers must, therefore, select materials from a standpoint of stiffness, as well as other aerodynamic characteristics.

Little emphasis has been given to the development of new materials for aerodynamic structures since the introduction of aluminum and magnesium to replace wood and fabric. However, the point has been reached where a new material capable of withstanding higher temperatures and greater stress must be employed so that further progress will not be limited by structural deficiencies.

PROBLEM NO. 94 (Cont)

There is a possibility that beryllium may be used as a structural material. This will be a major advance, since the modulus of elasticity to density ratio of beryllium is approximately seven times greater than that of any of the existing structural materials. However, beryllium is a highly toxic substance. In many of its chemical combinations it causes granulomata and can stimulate premalignant changes. Dust from beryllium and its compounds can cause irreversible lung changes. These limitations, therefore, may preclude the use of beryllium on a large scale. Additional areas of present research include:

a. Metal-bonded glass-fiber laminates

b. Prestressed ceramic or ceramic coated materials

c. Foaming of metals

d. Intermetallic compounds

e. Sandwich structures

f. Hollow, thinskinned structures of lightweight metals filled with high temperature resistant foams or reinforcing stress distributing materials.

g. Inorganic and organic high polymers for use at elevated temperatures.

PROBLEM NO. 95: Explosive Deformation in Metals, Manufacturing

Develop a practical manufacturing process that utilizes the pressure generated by explosives to modify ferrous and nonferrous metals to obtain exotic physical and mechanical properties.

BACKGROUND AND NEED: It has been empirically determined that the extreme pressures of an explosion significantly alter the properties of steel and produce characteristics that are not otherwise attainable. While this has, as yet, no practical utilization, it may provide an inexpensive, reproducible means of obtaining useable physical and mechanical properties not otherwise obtainable.

PROBLEM NO. 95 (Cont)

In the event the technique proves feasible, real advantages in process economy may be obtained since expensive machinery may not be necessary. Should desirable properties be obtained by this means and be beyond those conveniently obtainable, the gains would depend upon the nature of improvement but conceivably could be great.

PROBLEM NO. 96: Refractory Metals, Fabrication Techniques

Develop suitable fabrication techniques (forming and joining) for refractory metals. The methods must not permit the usual severe atmospheric reactions of the refractory metals at high temperature. They must also be capable of being mass produced.

BACKGROUND AND NEED: Due to the high affinity for oxygen and other atmospheric gases, various refractory metals (cobalt, niobium, molybdenum, tantalum, tungsten) when heated to forming temperatures, require large and expensive inert atmosphere equipment to completely envelop the metal and forming device. This arrangement in turn limits the unit size being produced. Forming methods are also limited by the low ductility and extreme stiffness of refractory metals. In addition, the high temperatures required for forming induce thermal stresses on present processing machinery. Some of these stresses may be decreased by plating forming rolls and dies with a material which is stronger and has a higher forming temperature. Present methods of fabrication are extremely expensive due to a high rate of rejection.

Solutions to this problem will open a vast field of used for the high strength, high temperature metals. Parts requiring these parameters could be made more economically and at higher production rates. Obviously, tremendous economies would be achieved in the manufacturing of metals for use in the missiles and space vehicle propulsion field and in the cores of nuclear reactors.

The ultimate objective in the solution to this problem is to develop techniques which would make refractory metals as workable and useable as steel.

PROBLEM NO. 97: Molecular Configuration, Alteration, Structural, Materials

Investigate means of altering the molecular configuration of structural materials to improve their mechanical properties.

BACKGROUND AND NEED: Alloying and mixing, as for example, the dispersion of intermetallic compounds, have been the conventional methods employed in improving the mechanical properties of materials. Recent work in ferromagnetic materials has resulted in changes in molecular structure and has led to improvements in electrical characteristics. However, no significant work has been done for the purpose of improving mechanical properties by molecular structure changes. There is a pressing need for airframe structural materials with improved mechanical properties such as increased stiffness, thermal stability, yield point, etc.

PROBLEM NO. 98: Dynamic Behavior of Linear and Non-linear Structures, Analysis

Develop improved analytical methods for determination of the dynamic behavior of linear and nonlinear structures likely to be encountered in missiles.

BACKGROUND AND NEED: A large number of analytical methods have been developed for computing natural modes and frequencies of linear structures, but the frequency estimates are inaccurate. Methods are being developed for estimating the lower bounds of simple plate structures. Advanced methods for the analysis of the lower bounds of built up structures are needed, so that the true frequencies can be bracketed. Many missile structures are non-linear, and tests yield results that cannot be understood on the basis of linear theory. Methods of analysis for non-linear structures are needed so that the aeroelastic effects can be appraised.

PROBLEM NO. 99: Rocket Engines, Propellants, Injection Of

Develop a self-pressurizing system for injection of propellants into liquid rocket engines.

BACKGROUND AND NEED: The present method of introducing propellants into the thrust chamber of liquid rocket engines involves either the use of pressurizing grains or turbopumps. Both of these

PROBLEM NO. 99 (Cont)

contribute weight and complexity to the operation of the engine. Yet, the propellants themselves afford a source of pressurization. The development of a self-pressurizing system involving the use of propellants initially installed in the fuel tanks would advance the state-of-the-art of liquid rocket engines considerably.

PROBLEM NO. 100: Sensors For Measurement Of Meteorological Parameters

Develop sensors for the instantaneous measurement of meteorological parameters and related atmospheric qualities with a high degree of accuracy especially for altitudes from 100,000 to 200,000 feet. Particular applications include sensors of the following types:

a. An inexpensive, expendable, sensor for measuring atmospheric pressure or density over an altitude range of 30,000 to 100,000 feet. The following characteristics are required: maximum package size, 1.4 inches diameter by 1.5 inches length; life span, 1 hour; response time, approximately 10 milliseconds maximum; output must be amenable to standard telemetering techniques; calibration accuracy, ±2 percent (may be decreased to ±5 percent, if necessary); and power used must be in milliwatt range.

b. An altitude sensor that operates independently of barometric pressure, with an accuracy of ±2000 feet at altitudes above 100,000 feet. Size must be kept to a minimum to permit use in small missiles.

c. Develop a technique for inflight analysis of air samples taken at altitudes over 100,000 feet.

BACKGROUND AND NEED: (Letter designations correspond to letter designations in the problem statement.)

Meteorological sensors now used for operational atmospheric soundings utilize the technique of measuring the effect of the parameter being sensed upon an easily measured property of the sensor which varies in a manner related to parameter variations. The sensor, then, must attain an equilibrium condition with the surrounding medium. In a rapidly changing condition or in a medium of extremely low density, the time lag in reaching equilibrium seriously affects the absolute accuracy of the measurement. At high altitudes where the mean free path of the air molecules may be many times

PROBLEM NO. 100 (Cont)

greater than the significant dimension of conventional sensors it appears that such techniques as counting the number of air molecules, measuring their mean kinetic energy of translation, and measuring their energy or random bombardment on a unit volume must be seriously considered.

a. The sensor will be sent aloft in a rocket and then returned to earth by parachute. The main problem is one of cost. An existing sensor meets the requirements except that the production cost is approximately $200. Since it is contemplated using these in 50,000 rockets a year, cost must be minimized.

b. The sensors may be active or passive. The main problem here is size and economy. Currently, barometric techniques are used at altitudes lower than 100,000 feet, and radar tracking devices for higher altitudes. This newly developed sensor would be used for upper atmosphere sounding probes. Ionization gages have been used but the power requirements for these gages are too high and they do not operate satisfactorily within the environment of the missile.

PROBLEM NO. 101: Power-Radio Package for Weather Stations

Develop a compact primary power-radio transmit package for automatic weather stations. Fuel and electronic components should be capable of unattended operation for a period of at least 6 months. The volume of the entire package should not be greater than 10 cubic feet with an RF power output of 500 watts, CW or modulated, transmitting simultaneously on two separate frequencies. Operation for a period of 10 minutes every 3 hours is a minimum requirement.

BACKGROUND AND NEED: At the present time, utilization of automatic weather stations at unattended locations has been severely restricted due to the lack of a dependable primary power source and a radio transmitter with an adequate RF power output. A standardized power-transmit package would simplify the design of automatic weather stations for practically all applications and, at the same time, overcome the basic problems listed above. Cost of the package in production should not exceed $1,000.

PROBLEM NO. 102: Sensor For Measurement Of Water Vapor Content Of Atmosphere

Develop a sensor which measures the water vapor content of the atmosphere for use in various automatic weather stations. The sensor should operate in ambient temperatures from +5°C to 50°C and should measure dew points from -5°C to +30°C with an accuracy of ±1°C. The weight of the sensor should be less than 3 pounds and its physical dimensions should be no greater than 6 inches by 6 inches by 10 inches. The sensor, with associated readout equipment, should operate within the above accuracies for a minimum of 1 year without maintenance or adjustment.

BACKGROUND AND NEED: Current models of automatic weather stations measure and telemeter meteorological parameters such as air and water temperatures, pressure, wind speed and direction, etc. At the present time a suitable humidity sensor is not available for use in automatic weather stations.

PROBLEM NO. 103: Sensing Device For Parachute Weather Buoy

Develop a sensing device with attachments that can be incorporated in the present Navy parachute weather buoy, to enable this buoy to be anchored by automatic means in water depths of 30 to 600 feet and measure wave heights and wave periods by a sensing device suspended at 30 to 40 feet. This device should have a magnetic tape recording, or other means, to provide a continuous record of wave measurements for a sufficient time interval, to permit trends as well as spot wave measurements to be included in the regular weather transmissions programmed on a schedule every 3 or 6 hours.

BACKGROUND AND NEED: The present state-of-the-art would point toward the use of a sensitive pressure sensor suspended under the floating buoy with an electrical cable leading to a recorder within the buoy itself. Although normal use of this wave measuring buoy would indicate regular radio transmissions programmed by a clock mechanism, it should have means of receiving a command signal which would immediately activate the station. All devices and attachments must be completely automatic to meet the urgent need for regular reports from unmanned locations.

PROBLEM NO. 104: Bearings in Light Metal Forgings

Develop improved methods for installing ball and roller bearings in light metal forgings and castings.

BACKGROUND AND NEED: Present methods of bearing installation involve various forms of local or ring staking or, in some instances, roll swaging to secure the bearings in cavities machined in forged or cast parts. The diametral fits within the cavities vary from zero to moderate interference. The metal displaced by the above securing methods is required to carry axial loads exerted on the bearings. Since the load carrying ability varies a great deal, axial movement of bearings has occurred even though the variation in load capability has been determined for production quantities under controlled conditions. Since all such bearings are treated as expendable and may be replaced prior to the expiration of the service life of the equipment, removal of the old bearing and reinstallation of new ones is difficult and, to some degree, unreliable. In addition, these methods introduce possible stress, corrosion, and fatigue problems dependent on the degree of control and care exercised.

PROBLEM NO. 105: Constant Frequency AC System

Present constant frequency primary ac electric systems require a constant speed drive or torque converter between the generator and its driving engine to maintain the generator at constant speed and frequency. Therefore, it is necessary to:

a. Develop a constant frequency ac system which will not require a constant speed drive or,

b. Develop dry toroid type mechanical constant speed drive systems for reliable nontransient ac electric power.

BACKGROUND AND NEED: Since the initiation of primary ac electric systems on aircraft, the constant speed drive (CSD) system has been a principal source of fleet problems within such systems. Present pneumatic, hydraulic and hydraulic differential type CS drives employed since the initiation of ac electric systems on aircraft, permit transients that require additional electro-mechanical components for the smoother power demands of electronic systems. New developments in electronics employing modular and micromodular components require stable nontransient power characteristics for optimum performance and reliability.

PROBLEM NO. 105 (Cont)

Ac systems of limited capacity that do not require a constant speed drive have been developed using vacuum tubes. However, these tubes are not suitable for use on aircraft due to the susceptibility of the tubes to damage from shock and vibration. The work on these systems is indicative that success can be expected in the development of higher capacity systems using semiconductors in conjunction with newly developed magnetic and insulating materials. A family of variable speed constant frequency systems rated from 5 to 60 KVA is needed.

The mechanical type CS drives recently developed indicate superiority over other type CS drives in providing nontransient output power. Six to 10 times torque can be produced by eliminating the fluid shear limitations of the toroid and substituting dry rolling friction between the rollers and toroids. This high torque capability, though not required for continuous output power, is the essential feature to provide the nontransient power characteristics.

PROBLEM NO. 106: Generators To Operate At Ambient Up to 250°C

Develop generators to operate at ambient temperatures up to 250°C. A family of ratings will be required ranging from 5 to 60 KVA.

BACKGROUND AND NEED: The temperature under which generators must operate is constantly increasing. Requirements for generators to operate at ambient temperatures above 120°C cannot be met directly with available equipment. The limitations imposed by existing materials have been overcome in a few cases by oil cooling the generators and in others by attaching a heat sink. These approaches lead to a complicated system in the case of the oil cooling and a heavy system when the heat sink is attached. There is need for generator development using newly developed materials which would result in a high temperature air cooled generator.

PROBLEM NO. 107: Printed Tape Cable, Applications For

Determine the applications for printed tape cable in both modern weapon systems and components therefor, and develop cable suitable for these applications. Handling and installation techniques and

PROBLEM NO. 107 (Cont)

particular accessories usually associated with cable installations, such as connectors, fasteners, terminals, blocks and clips should also be developed to assure a complete wiring system.

BACKGROUND AND NEED: Tape cable has the marked advantages of less weight and space requirements than conventional cable without sacrificing strength or current carrying capacity. The modern weapon system uses 22 gage wire as a minimum because of strength considerations. From a current carrying standpoint much of the wiring could be as small as 36 gage. Tape cable would fill this need without sacrificing reliability and would have the advantage of convenient mounting. Tape cable is also convenient for making branch-outs and tee connections.

PROBLEM NO. 108: Glass Fiber Coated With Metal

(Deleted)

PROBLEM NO. 109: Glass Flake, Production Technique

(Deleted)

PROBLEM NO. 110: Coating, Air-Dry, Heat Resistant Matrix

Develop a matrix or vehicle for use in an air-dry heat resistant coating. This could, conceivably, be a heat resistant polymer or a reaction product formed in situ on the surface being coated.

BACKGROUND AND NEED: The limiting factor for heat resistance of organic protective coatings is the degradation of the organic vehicle with heat. A requirement for air-drying coatings for practical production application imposes a further limitation in selecting potential materials. If suitable paint vehicles were available, paint formulations could be developed. In addition to military applications, such coatings would have extensive commercial applications which would be competitive without ceramic coatings.

PROBLEM NO. 111: Lubricant Permanent, Nonfluid

Develop nonfluid permanent lubricants for use at temperatures where the use of heat-resistant materials possessing high coefficients of friction may be expected and for use in handling cryogenic materials.

BACKGROUND AND NEED: Presently available fluid lubricants are generally organic and thus possess limited high temperature capabilities. Further, the plumbing required for their application occupies space and is abnormally sensitive to failure. The life and temperature resistance of dry film lubricants presently under development is approaching and, in some cases, has exceeded similar characteristics of fluid lubricants. Limited experience with dry film lubricants indicates that a considerable improvement may be expected. The film improvement can be accomplished by discovery of new materials with better lubricity at high and low temperatures, nonmigrating and flashing characteristics when subjected to vibration, and methods for repair of the film under operating conditions. Another requirement would be shelf life of 5 years.

The improved films would find application particularly in structures designed to operate at both high and low temperatures over long periods of time without attention.

PROBLEM NO. 112: Metal-Ceramic Mixture Compatability Of Components

Clarify the relationships which must exist between the properties of the components of a metal-ceramic mixture in order that they may be compatible and contribute, most effectively, to the strength of the composite.

BACKGROUND AND NEED: In order to fully exploit the potential advantages of metal-ceramic combinations such as metal strips, wires or fibers, in a ceramic matrix it would be very helpful to know what the relationships should be between properties such as coefficients of thermal expansion, moduli of elasticity, shear modulus of the matrix, and the dimensions of reinforcing fibers of known modulus, etc. This information would make it possible to select, rationally, the component parts of the metal-nonmetal combination in lieu of actual construction and testing of a potentially very large number of combinations.

PROBLEM NO. 113: Protection From High "G" Impact For Pilots

Develop equipment to protect pilots or spacemen from high "g" forces and impact forces of 100 g's.

BACKGROUND AND NEED: Based on freak accidents, it has been known for years that man can tolerate 100 g's impact force when properly supported and/or arrested. Considerable promise is held for custom molded exo-skeletons, such as found in certain insects. While mobility of the man must be maintained for control of the vehicle, it could be reduced during the crash or impact. An inertia triggering device might be used to cause an applicable restraint device to harden or become rigid. The device might need to contain ventilation features, and should have quick donning and doffing features. Application of the device would permit higher landing and impact speeds without the weight penalty of energy absorbing devices.

PROBLEM NO. 114: Fuel System Surge Pressures

Develop a method or technique to predict aircraft fuel system surge pressures.

BACKGROUND AND NEED: Methods of predicting peak pressure surges in fuel systems are needed for use during system design. At present, the method used to determine surges is to test a full scale fuel system mock-up in a test rig. Time delays and expensive system redesign at this stage could be eliminated if accurate values of surge pressure could be predicted.

PROBLEM NO. 115: Ground Effect Machine, Improvement Of

Develop methods for improving the lift to horsepower and lift to drag ratios of ground-effect-machines.

BACKGROUND AND NEED: The ground-effect-machine (GEM) has, in the last several years, received considerable attention and study. Basically, the GEM obtains its unique lifting characteristics by trapping a bubble of high pressure air under the base of the machine by means of some form of air seal about the perimeter of the base. The power requirements for hovering and low forward speeds are set by the air flow rate of the sealing air. If this air flow can be reduced without affecting the entrapped high pressure air, the lift

PROBLEM NO. 115 (Cont)

to horsepower ratio can be increased, thereby improving the hovering performance of the GEM.

An even more important problem is that of obtaining improved lift to drag ratios at high forward speeds. The ram drag associated with turning the direction of the airflow from a horizontal direction to the necessary vertical discharge direction is large and increases rapidly with increasing forward speed. The aerodynamic forces also increase with forward speed and it will be necessary to utilize these forces to the greatest degree possible. High speed GEM's will probably be configured like airplanes and will obtain an appreciable percent of the required lift from aerodynamic forces rather than the trapped high pressure air under the machines. The design problems, therefore, are to develop a GEM with an attractive lift-to drag ratio at high speed, competitive with other transportational vehicles as well as to improve the hovering performance by increasing the lift to horsepower ratio. Additional problem areas are to establish adequate control, stability, and spray suppression for the GEM.

Another area of interest is the Ground Effect Take-Off and Landing (GETOL) concept. This concept would combine the limited hovering height or vertical take-off ability of the GEM with the forward flight efficiency of the airplane. Herein the airplane can have a form of VTOL capability with a jet thrust-to-weight ratio of less than unity.

PROBLEM NO. 116: Recorder, Multiple-Channel

(Deleted)

PROBLEM NO. 117: Accident Recorder

Develop an indestructible device to record data in aircraft accidents.

BACKGROUND AND NEED: Modern high speed, high altitude aircraft have had an increasing number of accidents with neither survivors nor witnesses available. For example, in 1958 the cause was never fully established in about 40 percent of the fatal jet accidents. It is necessary that a device for recording the immediate circumstances preceding the accidents be developed and installed in all Navy aircraft. The device should have a radio or radar locator signal to aid in its location after separation from the aircraft. Also, it should be capable of floating.

PROBLEM NO. 118: Film Negative Processing and Duplication

Develop a system to completely process and duplicate roll film negatives in one operation.

BACKGROUND AND NEED: At the present time, an array of separate machines are used to process negatives, develop prints, and duplicate negatives. Considerable effort, with success, has been directed toward the design and development of automatic and semiautomatic processors and printers to accomplish these separate operations expeditiously. However, the use of a multiplicity of machines necessitates considerable time consuming handling of materials for transfer to and loading of each machine used. The urgent need to reduce the time cycle of this phase of photographic reconnaissance requires the various processing and reproduction operations to be combined and automated.

In order to accomplish this development, it is necessary that a study of the present state-of-the-art of processing and printing be conducted with a view toward combining the separate operations into a single system, completely programmed and automatically controlled.

PROBLEM NO. 119: Fuel Container Plastics, High Temperature

Develop high temperature plastics (above 500°F) suitable for use as fuel container materials that will also remain flexible at low temperatures.

BACKGROUND AND NEED: Teflon and Kel-F are now used as fuel container materials but they have 2 undesirable characteristics: they stiffen at moderately low temperatures and they melt at moderately high temperatures. Low temperature inflexibility prevents them from collapsing as the fuel is consumed and high temperature melting causes them to leak.

Many firms have developed high temperature plastics. Typical of these are a new series of modified polyester resins for reinforced plastic applications at high temperatures. These plastics will take, continuous exposure at 425°F and intermittent exposure at 500°F. However, these new materials also stiffen at low temperatures. For these reasons improvements are needed in these areas.

An area of potential interest which has been investigated is the inorganic polymer system which might lead to the discovery of an elastomer which will be stable to 1000°F.

PROBLEM NO. 120: Night Aerial Reconnaisance Equipment

Develop equipment for night aerial reconnaissance missions.

BACKGROUND AND NEED: Night aerial reconnaissance is presently limited to night photography achieved through the use of night cameras and pyrotechnic cartridges, bombs, or electronic flash units. These methods of illumination restrict the amount of night photography which can be obtained on one mission. In addition, these techniques are active; thereby increasing probability of detection and interception of the reconnaissance aircraft.

It is required that passive night aerial reconnaissance equipment be developed. This may be accomplished through the use of high speed emulsions and high light transmission camera lenses for ambient light, night photography. To permit longer exposures, it will be necessary to develop a night image velocity detector for control of the required image motion compensation devices. The use of infrared techniques should be investigated as a means of providing night reconnaissance photography at low altitudes and for sensing the ground velocity.

Another area requiring investigation is the guidance of the reconnaissance aircraft for night missions. Present photographic aircraft have no night navigation capability or they must rely on normal Plan Position Indicator (PPI) radar for their position determination. It is necessary that a passive navigation system be developed which is compatible with the reconnaissance aircraft and its camera control system. Inertial or infrared techniques may provide a solution in this area.

NEW PROBLEMS

The following additional problems have been recently submitted by field activities of the Bureau of Naval Weapons. These problems have been numbered so as to avoid duplication of numbers currently in use. The Table of Contents shows the "Old" and "New" groups of problems by categories. The Index, however, applies to both groups of problems arranged alphabetically.

Chapter 1

PROBLEMS IN ANTISUBMARINE WARFARE

PROBLEM NO. 121: Tactical Coordination of VA and H Aircraft

Develop a system for on-the-scene tactical coordination of fixed and rotary wing carrier-based aircraft when they are operating under IFR conditions around datum. Datum is defined as the last known position of a submarine. The purpose of the system would be:

a. To improve the efficiency of the ASE operation through better control of the individual aircraft's flight pattern.

b. To reduce the possibility of collisions between aircraft.

PROBLEM NO. 122: ASW Helicopter Systems

Both the ASW helicopter and the S2F airplane have the capability of carrying and utilizing multiple detection and classification systems. The helicopter has the obvious advantage of hover capabilities; however, such systems, other than the AN/ASQ-10 Sonar, need to be developed for adaption to the ASW helicopter.

PROBLEM NO. 123: ASW Computer for Locating Submarines

Develop an airborne ASW computer capable of receiving information from shore stations, AEW, FP, VS and HS aircraft and ASW ships. This computer should evaluate this information and predict the location of submarines.

PROBLEM NO. 124: Magnetic Anamoly Detectors (MAD), Extension of Range

The extension of the detection range of magnetic anamoly detectors (MAD) is essential to increase the capability of ASW aircraft.

BACKGROUND AND NEED: Present MAD equipment has proven to be one of the most effective means of localizing a submerged target in the final phases of an ASW problem. Recent advances in the state-of-the-art have provided more sensitive magnetometers

PROBLEM NO. 124 (Cont)

capable of increased range. Additional research in basic magnetic properties of matter is required to provide magnetometers with significant increase of detection range in order to improve MAD equipment as a search device. Sensitivity could then be reduced as the problem progresses for localization and eventual destruction of underwater targets.

PROBLEM NO. 125: Sonobuoy Systems Improvement

Sonobuoy systems capable of accurate localization of targets are needed. The sonobuoy should be simple and reliable with system complexity located in the aircraft.

BACKGROUND AND NEED: Present systems for sonic detection of submarines are ineffective as localization devices due to insufficient accuracy of processed data and/or insufficient data rate. Present passive systems require passing the problem to a different system after detection in order to prosecute an attack. Active systems are degraded by a slow data rate, inaccuracies, or by size, complexity and expense of the sonobuoy. Utilization of new techniques to improve both active and passive systems have shown improvements are possible and future developments are required to provide a system capable of fast, accurate detection, classification and localization.

PROBLEM NO. 126: ASW Aircraft, Sensors, Improvement Of

Better correlation and utilization of sensor information in an ASW aircraft is needed. This requires development of a data processing system, improved displays and accurate local area navigation DRT.

BACKGROUND AND NEED: The rapidly changing tactical situation and requirements for accurate relative position information for weapon drops impose severe requirements on the crew of an aircraft during an ASW problem. Automatic processing of data from the various sensors, accurate display of target data, and relative navigation information would enhance the kill probability. New ideas and techniques for minimizing the manual plotting of ASW information and presenting a complete picture of the situation as it develops to permit a rapid decision-making process will increase Fleet ASW capability.

PROBLEM NO. 127: Helicopter, Dipped Sonar Transducer, Tilt Angle

Develop a simple device (for installation in a helicopter) that indicates the tilt angle of a dipped sonar transducer.

BACKGROUND AND NEED: Experiments have shown that a sonar transducer and cable may tilt as much as 26 degrees under the effect of 1 knot movement incurred either by helicopter movement or submerged ocean currents. This tilt, combined with the vertical directivity of the transducer, can reduce the effective sonar range. A device indicating the relative direction and amount of tilt would enable the pilot to maneuver to reduce the tilt and, hence, improve sonar performance.

PROBLEM NO. 128: Underwater Targets, Long Range Detection, Classification, Localization

Develop equipments utilizing new techniques for long range detection, classification, and localization of underwater targets. An immediate improvement is needed in the method by which submarines can identify detected targets.

BACKGROUND AND NEED: Most of the improvements in ASW capability since World War II have occurred as a result of improvements in the utilization of the techniques and phenomena used for ASW during the war.

The possibility of discovering new phenomena applicable to ASW operations exists. Research in the fields of oceanography and basic physics may develop new equipments which will provide orders of magnitude improvement in ASW capabilities.

When a submarine has detected the presence of an unknown vessel, the only identification method now available is to track the target for an extended period of time and attempt communication. To complicate the problem, ambient sea noise affects acoustic transmission and may be confused with sounds from enemy or friendly submarines.

Several approaches to this problem have been suggested. The following merit further consideration:

a. Emit a coded noise signal of volume less than the background noise; the radiated signal would be kept weaker than the known ambient sound radiation level and identified by the use of autocorrelation techniques.

PROBLEM NO. 128 (Cont)

b. Emit signals similar to the sounds produced by marine animals, from which coded signals could be extracted.

Chapter 2

PROBLEMS IN ANTI-AIR WARFARE

Notice: The Bureau of Naval Weapons has not received any unclassified "New" problems in the area of Anti-Air Warfare.

Chapter 3

PROBLEMS IN STRIKE WARFARE

Notice: The Bureau of Naval Weapons has not received any unclassified "New" problems in the area of Strike Warfare.

Chapter 4

PROBLEMS IN SUPPORT EQUIPMENT

PROBLEM NO. 129: Anticollision Device

Develop an anticollision device for aircraft that signals the pilot when evasive action is required.

PROBLEM NO. 130: Boom, Refueling, Ship

Develop a ship's underway refueling and replenishment boom which could be extended by the provisioning ship and automatically or semiautomatically engaged by the receiving ship.

PROBLEM NO. 131: Airspeed Measuring Method

Develop a new method of measuring airspeeds for airplanes to eliminate position error.

Develop an accurate (±1 knot) low speed 0 to 30 knots airspeed indicator for VTOL/STOL aircraft.

BACKGROUND AND NEED: Airspeed pressure sensing instruments are presently compromised by position errors, compressibility corrections and changing calibrations. Complex electronic and mechanical equipment is presently needed to convert and correct pressure sensed measurements into useful parameters for display as well as for use in weapons systems.

Although considerable work has been attempted, and is still being continued in this area, no known instrument has been developed that will give accurate results in the 0 to 30 knots airspeed region. This information is required for instrument flight involving steep approaches and climb-out, rescue and cargo pickup where aerology data are not available, and low speed high gross weight operation of VTOL/STOL aircraft.

PROBLEM NO. 132: Indication To "Go Home"

Develop a system in conjunction with TACAN to provide the intercept pilot with a cockpit "go home" indication.

PROBLEM NO. 132 (Cont)

BACKGROUND AND NEED: The enormity of present-day airplane fuel consumption during combat conditions contributes sizably to the dangers that attend intercept training. It also limits the training of the man-machine system to far less than maximum capability. Because of variant temperatures, speeds and altitudes, the pilot can seldom predict the distance from which he can safely return during intercept training exercises. A suggested system might be a simplified version of FREDI (Flight Range and Endurance Data Indicator) with only one parameter display in the cockpit.

PROBLEM NO. 133: Transducer For Digital Readout

Develop a fast response digital readout for transducers. Present digital readout systems have a frequency response which is too low for transducers used for dynamic flight test measurements. The desired readout should have a frequency response of at least 100 cycles per second. This is needed for laboratory calibration of flight test transducers.

PROBLEM NO. 134: Survival Equipment, Miniaturized

Development of the following miniaturized survival equipment:

a. Signal devices:

(1) Flares
(2) Smoke flares:

(a) Long burning surface
(b) Short burning air burst

(3) Dye markers
(4) Small caliber combination tracer star shells, i.e., approximately .38 or .45 caliber

b. Shark repellent

c. Winter survival mittens, compressed by vacuum pack and sealed in waterproof tear-open container

d. Winter survival inflatable hood, compressed by vacuum pack and sealed in waterproof tear-open container

PROBLEM NO. 134 (Cont)

e. Life rafts and life preserver vests

PROBLEM NO. 135: Inflator For Automatic Filling of Life Rafts and Vests

Develop a reliable device to automatically inflate life rafts and life vests when a parachutist enters the water.

PROBLEM NO. 136: Signal Release in Search and Surveillance Radar Sets

Develop a device that will trigger a signal system in search and surveillance type radar sets either when an aircraft escape system is activated or when the parachute is deployed.

PROBLEM NO. 137: Bore-Scope For Inspection of Inaccessible Engine Components

Develop a bore-scope for inspection of inaccessible engine components.

PROBLEM NO. 138: Compressor, Air, Portable, Lightweight, Gasoline Driven

Develop a portable, lightweight, gasoline driven air compressor with an output of 120 pounds per square inch and a volume of 5 cubic feet per minute.

PROBLEM NO. 139: Air Ducts For Jet Engine Starters

Develop lightweight, but ruggedly constructed, air ducts for jet engine starters. The ducts should withstand temperatures up to 800°F and pressures up to 250 pounds per square inch.

PROBLEM NO. 140: Sonar, Smaller, Faster Scanning Dipped

Develop more powerful, faster sinking, smaller and faster scanning dipped sonars.

PROBLEM NO. 140 (Cont)

BACKGROUND AND NEED: A continuous development program in airborne sonar equipments is needed in order to provide the best equipment possible for the carrying vehicle. The older equipments lose effectiveness due to the time required for a 360 degree scan. The latest equipment is a significant improvement; however, its complexity and size requires a large, powerful platform to transport it. Applications presently exist for small sonar equipments (which could be carried in small helicopters) capable of operation on destroyers, auxiliaries, and merchant ships.

PROBLEM NO. 141: Sonic System Components

Improvements in sonic system components are required in order to improve reliability and capability of airborne systems. Specifically, light, rugged, and reliable cables and hydrophones capable of withstanding high hydrostatic pressures without leaking are required.

BACKGROUND AND NEED: A history of failures of sonobuoys has shown that a majority are due to mechanical rather than electrical defects. Loss of acoustic information due to shorts incurred by water leakage in the hydrophone and its cable have occurred even under conditions of low hydrostatic pressure. Sonobuoy systems require that cable and hydrophones be lightweight and small in size in order to be packaged in the droppable container and the cable shielding maintains a high degree of watertight integrity.

PROBLEM NO. 142: Adhesive for Bonding Metal-To-Metal

Develop an adhesive for bonding metal-to-metal that is not sensitive to shock. The bond must hold against a small given stress (pounds per square inch) but must give way easily when that stress is exceeded.

BACKGROUND AND NEED: There is an existing metal bonding adhesive that is quite brittle and can be broken with a sharp blow (as by a hammer) but it is unable to withstand air drops. The retaining of the quick break-away feature, coupled with shock resistance, is required in this problem.

PROBLEM NO. 143: Depth Recorders

Develop the following types of depth recorders:

a. A simple, easily serviced depth recorder with a range from 0 to 3000 feet with an accuracy of ± 1/2 percent of full scale. The size should be approximately 6 inches in diameter by 9 inches in length.

b. A depth or hydraulic pressure recorder with an accuracy of ±0.1 percent. It must be capable of measurement up to 15,000 pounds per square inch. The instrument may be linear or nonlinear but the results must be reproducible.

BACKGROUND AND NEED: (Letter designations in this section correspond to letter designations in the problem statement.)

a. This unit would be mounted on a slowly moving sounding vehicle. The primary problem is to decrease the size and complexity of the instrument. The existing unit measures 1 foot in diameter by 2 feet in length and is exceedingly complicated. Operation time of the unit would be several hours.

b. This unit will be lowered into the sea at a constant rate. Increased accuracy is the major problem as current units have only ±1 percent accuracy.

PROBLEM NO. 144: Switch, Electrically Actuated

Develop an electrically actuated switch that requires an operating energy between 30 ergs and 1 joule and meets standard aircraft vibration requirements.

BACKGROUND AND NEED: This switch would be used to provide protection from RF actuation since more energy would be required to operate the switch than is available from RF.

PROBLEM NO. 145: Phase Meter, Direct Readout

A need exists for a phase meter having direct readout with a dc signal proportional to the phase and the capability of rejecting all components of a complex wave except the fundamental.

PROBLEM NO. 145 (Cont)

BACKGROUND AND NEED: Currently, phase meters measure the time differential of 2 signals as the signals cross a reference value. If the signals have many harmonics, multiple crossings occur and the measurements must be approximated with resulting inaccuracy.

A device is needed to measure direct mechanical impedance. However, development is not possible at this time since it is impossible to take into consideration the relative phase of the signal proportional to the force and velocity components of the impedance. Development of the phase meter specified in this problem would make the design of this impedance meter a relatively simple task. This is only one example of the many applications in which such a meter could be used.

PROBLEM NO. 146: Accelerometers, Calibration Of

Develop laboratory equipment for the calibration of accelerometers. The equipment must produce accurate, known "g" forces up to at least 10,000 g's ±1 percent. The pulse duration must be capable of variation in time parameters from 50 microseconds to 5 milliseconds ±1 percent.

BACKGROUND AND NEED: Currently, accelerometers are calibrated at 1 g and are assumed to be linear up to 10,000 or 40,000 g's.

PROBLEM NO. 147: Tension of Shipboard Cables in Motion

Develop a portable, easily installed device to measure and record the tension of moving cables on shipboard.

BACKGROUND AND NEED: When new aircraft is first introduced into the fleet, a knowledge of the tensions in the arresting cables would be advantageous. Since shipboard installations cannot be modified to utilize test site equipment, much valuable information is lost. A device which could be easily installed on the cables to accurately measure tension is desired.

PROBLEM NO. 148: Servo, Electrically-Stimulated Force or Torque Producing

Develop an electrically-stimulated force or torque-producing servo with 0.5 percent friction which is independent of its output position or velocity. A 10 to 15 pound-inch torque range is desired.

BACKGROUND AND NEED: In a guided missile, one may elect to stabilize the homing radar dish by creating, as an integral part of it, a spinning mass or free gyro which spins on the radar dish axis. In order for the dish to track a target with a space rate, the gyro must precess at the desired space rate.

For example, if an external force is applied on a radar dish and gyro assembly at 12 o'clock, it will look left or right with no motion occurring along the axis of force application. Again, if a force is applied at 3 o'clock, the dish will look up or down. Now, if a force is applied at both 12 and 3 o'clock, the dish will look into a compound plane and each point of force application will experience motion, but in proportion to the force applied at the other point. The driving members in this arrangement are said to be cross-coupled where a force in one actuator causes a motion in the other. Friction within the servo actuators causes crosstalk, which is very undesirable.

The present art utilizes gear trains, harmonic drives, dc motors and magnetic particle clutches in various combinations. Drawbacks to these systems are backlash, starting torque, bearing friction, brush friction, and a force or torque dependence upon output shaft motion. The needed device, being airborne, should be lightweight and low volume.

PROBLEM NO. 149: Bathythermograph Buoy

Develop an expendable bathythermograph buoy capable of recording water temperatures from 0 to 500 feet. Accurate knowledge of the first 15 feet is particularly needed.

BACKGROUND AND NEED: More information on oceanographic conditions is required in order to effectively utilize present ASW equipments and develop new equipments. Aircraft is capable of collecting certain types of data over relatively large ocean areas in short periods of time. A low cost expendable bathythermograph could provide temperature gradient information to a collecting

PROBLEM NO. 149 (Cont)

aircraft. Accurate knowledge of near surface temperatures is required for correlation with internally carried sensors in the aircraft.

PROBLEM NO. 150: Camera, Television, Low Light Level For Detecting Submarines

Develop a low light level television camera capable of detecting submarines at night as a replacement for the present ASW searchlight.

BACKGROUND AND NEED: Present television cameras are insensitive to extremely low light. Vidicons require too much integration time for an airborne TV set. An 0.03 second integration time should give maximum sensitivity. Research to reduce interdependent controls to one level control is needed. A dynamic light level control for operation from one millionth foot candles to about 100 foot candles is required. In addition, low light TV camera tubes should be made more rugged.

PROBLEM NO. 151: Film Brightness Exposure Control Device

Develop an automatic exposure control device to provide exposure information for maximum and minimum brightness as required for the performance of critical airborne photographic reconnaissance.

BACKGROUND AND NEED: Present automatic exposure control systems are limited to a photoelectric sensing device which produces an output signal proportional to the integrated terrain brightness. This type of sensing device will not provide the correct exposure for image details in shaded areas or highly reflective areas and reacts to false information from clouds. A scanning type of terrain brightness sensing unit which will indicate the range of brightness and permit selective control for any desired portion of this range is required.

PROBLEM NO. 152: Airspeed Measuring System, Helicopter

Present airspeed measuring systems in helicopters lack the accuracy required for flight control and navigation purposes when the aircraft is flying at low airspeeds. Although more complicated

PROBLEM NO. 152 (Cont)

systems, such as those using doppler and inertial techniques, may provide the information required for control and navigation, a simple and accurate airspeed measuring device would reduce the demands on such systems and would provide a valuable backup capability.

BACKGROUND AND NEED: Current pitot-static airspeed indicators and transducers do not provide accurate indications or output signals at low airspeeds because of the effect of the rotor wash on the pitot-static pressures. Attempts to improve the airspeed accuracy by using various pitot-static configurations and locations have not produced the required results. Major improvements, or an entirely new approach, are needed to solve the airspeed measurement problem.

PROBLEM NO. 153: Fuel Quantity Measuring Systems

A major improvement is required in the dependability of fuel quantity measuring systems for Naval aircraft.

BACKGROUND AND NEED: The present capacitance type fuel quantity systems lack dependability for two basic reasons: first, the capacitance probes can be made inoperable by water or other foreign matter in the fuel; and second, the large number of capacitance probes required to give accurate indication under various attitude conditions greatly increases the probability of connector and cable failures. Major improvements are needed in present systems, particularly with respect to tank probes and associated connectors and cables. An entirely new approach to fuel quantity measurement may be the long range solution to the current problems.

PROBLEM NO. 154: Electric Power Equipment, Conversion, Inversion and Regulation

Develop static equipment for conversion, inversion and regulation of electric power, which conform to the radio interference requirements of MIL-I-6181D.

BACKGROUND AND NEED: The state-of-the-art in producing semiconductor devices has advanced to the stage where they are being applied to aircraft power conversion, inversion and regulating equipment. Static inverters in the range of 100 to 1500

PROBLEM NO. 154 (Cont)

volt-amperes are being developed. These equipments will provide a maintenance free 85°C inverter for retrofit purposes in military aircraft, but unlike conventional equipment, they do not conform to the radio interference requirements of MIL-I-6181D. The low frequency range (.15 to 3 megacycles) is the spectrum of greatest discrepancy; with interference levels 6 to 10 times the MIL-I-6181D limits. New semiconductors and new application techniques are required in order to produce conversion, inversion and regulation equipment which is acceptably free from radio interference.

PROBLEM NO. 155: Electric Lamps, High Performance Naval Aircraft

Develop a line of electric lamps for aircraft exterior lights which will produce the required luminous output and have sufficient life when subjected to the operating conditions of high performance (supersonic) Naval aircraft.

BACKGROUND AND NEED: Most electric lamps available today, for installation on high performance aircraft, were originally developed for use on subsonic aircraft where their performance has been generally satisfactory. Exterior lights designed for supersonic aircraft should have greatly increased luminous output because higher aircraft closing speeds demand detection of aircraft light at far greater distances than are required for subsonic aircraft. At the same time the limitations on available space tend to greatly aggravate the problem of increasing light output. The environmental conditions imposed by supersonic aircraft, particularly those of heat, vibration and shock have resulted in excessively high lamp failure rates. The use of vibration isolators has not provided an adequate solution because of the severe space and temperature requirements.

PROBLEM NO. 156: Audio Amplifier, Supersensitive

Develop a supersensitive audio amplifier which will pick up and amplify signal voltage of 1 microvolt to 1 nanovolt in the audio range and give a gain of 1000 decibels.

BACKGROUND AND NEED: Present work in solid state detectors is limited in the range of impedance (too low). This requires complicated and space consuming circuitry.

PROBLEM NO. 157: Tracking Device, Range Telemetry

Develop a tracking device for range telemetry of a missile test range which uses the principle of electronics for acquisition and display of missile flight test data. This instrument would perform the same function as, and replace, present optical tracking cameras. The system should provide continuous numerical data readout representing the geometry of the missile flight path paralleled by a video presentation. The whole system should be very accurate in establishing reference planes and location of the test vehicle relative to such reference.

BACKGROUND AND NEED: Present camera tracking devices do not have the desired accuracy and require complicated, time consuming and costly processing to provide accurate location data on the test missile during flight path.

PROBLEM NO. 158: Gyroscope Drift Rate, Measurement

Develop a relatively quick way to measure gyroscope drift rate when the rate is 0.001 degree per hour or less.

BACKGROUND AND NEED: At the present time, measurement of gyro drift rate (where the drift rate is on the order of 0.001 degree per hour) involves test periods that extend for many hours. It should be possible to make such tests in a few hours.

Present equatorial rate tables are sufficiently accurate for testing today's gyros, but gyro accuracy will be improved by new developments. Improved testing devices and methods must be developed to complement the gyro improvements.

PROBLEM NO. 159: Switch, Pressure Sensing

Develop a pressure sensing switch which will actuate at low pressures and can be subjected to pressures of a much greater magnitude without requiring replacement or recalibration after each pressurization. The device should have the following capabilities:

a. Actuation at 50 PSIG
b. Withstanding of 2500 PSIG

PROBLEM NO. 159 (Cont)

BACKGROUND AND NEED: The sensing switch is to be used to actuare Polaris test vehicle recovery systems at the instant of first response to launch command by the missile eject system.

PROBLEM NO. 160: Bearing, Needle or Ball, Using Hydraulic Fluid for Lubrication

Develop a high speed, low drag needle or ball bearing that is capable of using hydraulic fluids as a lubricant.

BACKGROUND AND NEED: In many installations, bearings must be protected from hydraulic fluid. Such protection has often caused failures and proved inadequate. The lower viscosity limit of the hydraulic fluid that would be used as a lubricant for the bearing would be approximately 7 centistokes.

PROBLEM NO. 161: Microwave Limiters

Develop the following types of microwave limiters:

a. A low level (microvolt region), low noise, microwave limiter.

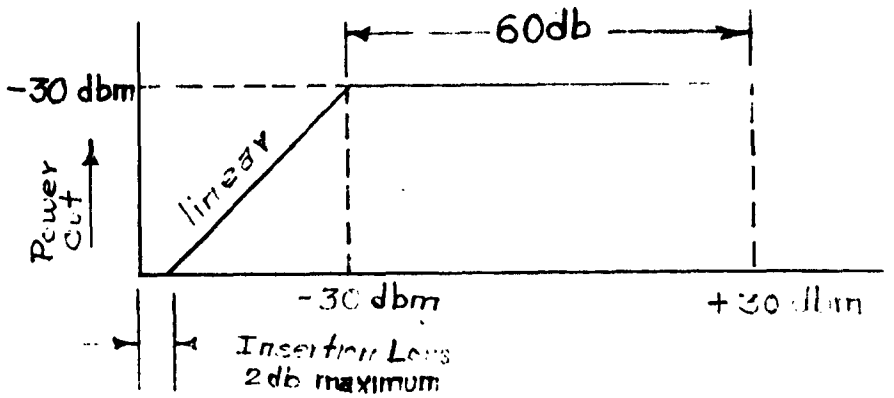
b. A microwave power limiter to limit amount of power passed to the RF mixer. It should limit power to 30 decibels below one milliwatt (-30 dbm) with a maximum search and loss of 60 decibels. It is intended for use in the X and K bands and must withstand 1 watt power input with no permanent change in its characteristics. Band width equal to ±5 percent.

BACKGROUND AND NEED: (Letter designations in this section correspond with letter designations in the problem statement.)

a. Present microwave limiters do not operate in the microvolt region. It would be desirable to place a limiter in the coaxial line or waveguide of a radar set to prevent the signal from exceeding a maximum value and entering the receiver circuitry, disrupting the sensitivity, etc.

b. Present devices only limit to 0 dbm and require cascaded components to give a 60 decibel dynamic range. The following is an ideal curve of the requirements desired.

PROBLEM NO. 161 (Cont)



PROBLEM NO. 162: Variable Controls, Rocket Motor, Testing

In the testing of rocket motors, it is often desirable to vary the controls over the same complex pattern for several tests. The procedure is to record the control command signals on magnetic tape. Conversion of the desired pattern from graphical representation to an analog signal now requires use of special complex circuits designed to simulate the pattern.

BACKGROUND AND NEED: An easy and inexpensive method of generating this complex pattern is required. This procedure would cover the field of dynamic testing as well as rocket motor testing. The required accuracy is 1 percent on profile. The cost is presently $2000 per tape. This procedure would also permit easy change of pattern.

PROBLEM NO. 163: Connectors and Cables, Rocket Motor Testing

Develop connectors and cables to be used in rocket motor testing in high altitude simulation chambers in any of the following conditions: high temperatures (1000°F to 4000°F), high altitude (100,000 feet), water, steam, and gases. In addition, the cable must be of low noise type and its characteristics (e.g., capacitance) must not change with temperature.

PROBLEM NO. 163 (Cont)

BACKGROUND AND NEED: The connectors now used cost $150 each and are good only for a few tests. Fifty or more connectors are used in one test stand. This type of testing is widely used, i.e., a condition in which the motor runs for about 1 minute and a pressure differential is applied for a longer period.

PROBLEM NO. 164: Pressure Transducer Supports, Rocket Motor Testing

Eliminate the mechanical supports presently used for the pressure transducers during tests of rocket motors, retaining use of the same transducers.

BACKGROUND AND NEED: Pressure transducers which are used in the testing of rocket motors are very accurate. They weigh approximately 5 pounds each and are individually supported since the line to which they are attached cannot support them. Approximately 50 of these pressure transducers are used in the testing of each rocket motor. Their mechanical supports are neither economical nor readily available; consequently, test costs are markedly increased by their use. The transducers also tend to make the lines in which they are installed resonant at lower frequencies creating more difficulties.

PROBLEM NO. 165: Flow Meter, Special Fluids

A need exists for flow meters which may be used with highly corrosive fluids (e.g., red fuming nitric acid), "slush" or "jelly" compounds or related materials which change viscosity. There is also a need for good resolution (1 percent) from 1/2 gallon to 40 gallons per minute in these meters.

BACKGROUND AND NEED: Some flow meters are now made from stainless materials but these do not give the accuracy over the range required. An approach to this problem would be to measure the instantaneous viscosity and rate of flow.

Present flow meters cannot be used over the wide range required (1/2 gallon to 40 gallons per minute). Although the meters show the required accuracy within a very limited range, this accuracy cannot be maintained over the entire range of flow rate.

PROBLEM NO. 166: Transducers, Overload Rating

Develop transducers (load cells) that can withstand overloads of 150 percent of rated load.

BACKGROUND AND NEED: The present method is to use a load cell rated at 150 percent of desired rated load, but this results in a reduction in measurement accuracy in the 0 to 100 percent of rated load region where most of the testing is carried out. Also, the dynamic characteristics of load cells are not now known.

PROBLEM NO. 167: Fuel Cells, Improved Performance

Many fuel cells have short life (minute, hour or day). The need is for a cell that will run continuously for many hours without overhaul. Fuels should be easily handled. Piping under moderate pressure would be acceptable.

BACKGROUND AND NEED: One hundred pounds per horsepower is characteristic of presently available fuel cells. High energy fuel cells should be used and the risks associated with the use of such fuels (e.g. hydrogen) are acceptable.

Comments on present fuel cells are as follows: high weight per horsepower; low output (watts per square inch), about 0.1 watt per square inch is available; fuel economy is alright.

The reasons for the above are as follows: Reacting materials are either of low relative energy (seldom the problem) or of high reactive threshold (hard to get them to react) which restricts the rate of reaction; and, poor solubility of the reactants in solution (i.e., reactants are in a very diluted solution).

Unusual fuels are acceptable for military and scientific use. The importance of the job renders fuel expense a minor consideration.

PROBLEM NO. 168: Timers, Special Types

Develop the following types of timers:

a. An inexpensive self-contained timer that produces a fixed frequency square wave (variable from 1 to 500 cycles per second). Total cost objective is $25 per unit.

PROBLEM NO. 168 (Cont)

b. Develop a highly reliable timer with an accuracy of ±0.1 percent for 60 days. Cost objective is less than $100 per unit.

BACKGROUND AND NEED: (Letter designations in this section correspond to letter designations in the problem statement.)

a. This unit should be designed to meet aircraft vibration specifications and withstand 250 g's deceleration. Although the normal operating period of the timer is only 1 hour, the unit should be designed to have an operating life of 24 hours. An accuracy of ±1 percent is required over the 24 hour period. The unit must be self-contained (no external power source) within a 1 cubic inch volume.

b. Present electrolytic silver wire lead bead timer has an accuracy of only 3 percent to 10 percent. Possibly, an electric clock or transistorized sealed circuit could be used. An urgent need for a solution to this particular problem exists.

PROBLEM NO. 169: Dielectric Covers for Slotted Waveguides and Adhesives For

Develop high temperature, dielectric covers for slotted waveguides and adhesives for mounting such covers. The covers must withstand an internal pressure much greater than the ambient pressure found at high altitudes. The following characteristics are required:

a. Capable of hermetic seal to stainless steel

b. Low value of ϵ 2 (approximately)

c. ϵ variation must be less than 20 percent during production

d. Thickness 0.010 inches to 0.040 inches

e. Thermal expansion coefficient within 20 percent of that of stainless steel.

f. Loss tangent .001 or less at microwave frequencies.

BACKGROUND AND NEED: Present slotted waveguide covers are made of Teflon impregnated fiber glass and are held in place by

PROBLEM NO. 169 (Cont)

adhesives which provide the hermetic seal. This material is not suitable for use at high altitudes and temperatures; new materials must be found. Pyroceram has most of the desired properties but it is too brittle and its ϵ value at 5.6 is too high. As the waveguide is pressurized, the low external pressure at high altitudes develops too great a pressure differential and the present covers tend to pop off.

PROBLEM NO. 170: RF Filters for Telemetry Systems

Develop RF filters for 1400 to 2200 megacycles range for use in telemetry systems. These filters should be of a narrow band (several megacycles) with low insertion loss and tunable over approximately 100 megacycles.

BACKGROUND AND NEED: Present narrow band filters have too high an insertion loss. At this time, scientific research has no solution to this problem.

PROBLEM NO. 171: Electrostatic Printing, Stili For

Electrostatic printing equipment does not give uniform printing density across the page, i.e., the stili erode. Present stili have a high cost, a few hours life and very low reliability.

BACKGROUND AND NEED: Approximately 1000 stili are used in a 10 inch line for electrostatic printing. A new approach to the methods and procedures of electrostatic printing is needed. Elimination of the spark at the stili would be a step in the right direction. Currently, the printing character is dependent upon humidity.

PROBLEM NO. 172: Torpedo-Submarine, Miss-Distance Indicator

Develop a miss-distance indicator for torpedo-submarine encounters.

BACKGROUND AND NEED: Torpedo pingers which are now used are unreliable and inaccurate. This type system depends too much on the torpedo. The accuracy desired is 50 percent of target size (50 percent of 30 feet by 300 feet) plus orientation of encounter.

PROBLEM NO. 173: Meteorological Instruments

Develop improved meteorological detecting, measuring, transmitting, and recording instruments for use at airfields.

BACKGROUND AND NEED: Instruments to perform the following functions are needed either as entirely new instruments or as improvements over existing instruments. There is a need for:

a. An instrument to sense cloud heights -- the present instrument, ceilometer, is not adequate. Some means other than radar is needed. A suggested method would be a stroboscopic flash of light. The cost for such an instrument should be in the range of $2000 to $3000.

b. An instrument to measure the visibility -- a transmissometer is now being used.

(1) A combined instrument to perform the functions of (a) and (b).

c. A simple, inexpensive instrument to be used to transmit information from remote points to detecting points. A particular example would be on airfields where instruments for (a) and (b) above are in use. Presently the cost of cable from the instruments to the control tower is greater than the cost of the instruments.

d. An instrument to sense relative humidity. The instrument presently in use does not operate satisfactorily at low temperature.

e. A multipurpose instrument to measure the parameters indicated in (a) through (d). This particular instrument should have a means of cancelling out the existing noises, vibrations, etc., which surround the airfield where the instrument is being used.

f. An instrument to detect average visibility in all directions.

g. A sensing device to detect sky covering and give a peripheral view.

h. A sensing device to detect and identify precipitation, e.g., rain, snow, sleet, etc.

i. A sensing device to detect obstructions to vision in fog, haze, etc.

PROBLEM NO. 173 (Cont)

j. A single station spherics detector to detect lightning, etc., and transmit the information to a receiver which will present the information in an identifiable form, e. g., polar coordinates.

Chapter 5

PROBLEMS IN SUPPORTING RESEARCH

PROBLEM NO. 174: Automatic Pilot for Terrain Clearance

Develop an automatic pilot for terrain clearance. A requirement for automatic terrain-following flight exists in all low flying strike airplanes. The present technique of manually piloting the airplane through guidance from a terrain clearance display is too time-demanding and exhausting for more than a few minutes of such flight.

PROBLEM NO. 175: Radiation Pattern, Instrumentation System For Aircraft

Develop a packaged instrumentation system which can be easily installed in an airplane and will make it possible to determine the radiation pattern in the azimuth plane of various antennas on the airplane by means of a small number of orbits or other simple maneuvers.

BACKGROUND AND NEED: The principal method of determining an airplane antenna radiation pattern has been to conduct a clover-leaf flight pattern (15 degrees increments of heading change) over an established ground check point while the signal from the airplane is recorded at a ground station. The result is a pattern of the antenna radiation in the horizontal plane. Less precise information about the patterns at 15, 30, and 45 degrees above and below the horizon is obtained by flying the airplane in banked circles about the check point. The whole procedure is extremely costly, time consuming and subject to error.

PROBLEM NO. 176: Pitch and Roll Measure

Develop an improved method to measure pitch and roll throughout 360 degrees within a test aircraft.

BACKGROUND AND NEED: Presently used attitude gyros are not free in both directions. Usually, they are free in one direction and good for only about ±80 degrees in the other. There are special platforms available which will give the desired measurements but these are extremely sensitive and cumbersome. What is needed is a small airborne package for test purposes.

PROBLEM NO. 177: Sink Measuring For Aircraft After Catapulting

a. Develop a quick-look velocity indicator for aircraft on deck (landing or catapulting).

b. Develop means of measuring the sink of an aircraft immediately after catapulting from an aircraft carrier.

BACKGROUND AND NEED: In carrier suitability tests, engaging and catapulting velocities should be accurately determined. This is accomplished primarily by photographic means. This method is reliable but does not provide on-site information. Existing electrical and electro-optical instruments for quick readout are troublesome and subject to error for various reasons. It would be desirable to make these measurements with a Polaroid-type camera which records successive images on the same film with known timing between images.

Under minimum wind velocity launching tests, it is necessary to measure the sink of an aircraft immediately after launching in order to completely evaluate its performance under these considerations. Present methods utilizing photography do not provide satisfactory results, since the camera is located on the deck, which is usually rising and falling. What is needed is a compact pressure sensing device or inertial device which will give a measure of the vertical displacement from the point of departure from the deck.

PROBLEM NO. 178: Galvanometer For Oscillograph

Develop a galvanometer for oscillograph use which will be less susceptible to mechanical damage.

BACKGROUND AND NEED: Present D'Arsonval type galvanometers used in recording oscillographs are frequently damaged when the oscillograph is subjected to acceleration and shock loads. A galvanometer without delicate suspensions would eliminate this problem. Possibly, a new principle, such as utilizing the electrical deformation of a crystal to deflect a light beam, would be a solution.

PROBLEM NO. 179: Vibration Analyzer For Turbine Engines

Develop an airborne vibration analyzer for turbine engines that will forecast engine and/or component failure to the pilot.

PROBLEM NO. 180: Combustion and Oxidation Products Analyzer

Develop a field instrument for rapidly analyzing combustion and partial oxidation products of JP fuels and synthetic lubricating oils used in jet and turbojet engines.

PROBLEM NO. 181: Microwave Source, Solid State C-Band, CW, Develop

Develop a solid state C-band CW microwave source which would replace the klystron oscillator tube used in most microwave receivers. The device should be capable of being electrically tuned over a 5 percent to 10 percent band width, have a minimum power output of 10 to 20 milliwatts and be essentially free of AM and FM noise sidebands. Small size, lightweight and minimum power consumption are important objectives.

BACKGROUND AND NEED: Guided missiles employing microwave receivers have been seriously handicapped, for reasons listed below, in not having a wide operating frequency range that is readily selectable by remote control.

a. Restricted operating band widths of 1 to 3 percent have caused a serious frequency assignment and interference problem.

b. Microphonic noise, even in ruggedized klystron tubes, limits the performance of the CW homing systems and also requires elaborate, difficult, and time consuming tests aboard ship.

c. Slow warmup of klystrons is a major factor in the launcher cycling time (fire power).

d. Frequency drift of a klystron requires guard bands to be placed around a particular assignment to prevent false AFC, thereby reducing the number of channel assignments available.

e. The power consumed by 1 klystron tube is 60 to 85 percent of the total required by the receiver.

The possibility of developing a solid-state microwave source using nonlinear diode multipliers has existed for about 2 years. A few organizations have been active in this field but success is not yet apparent. The design of 1 guidance system, now under development, requires a multifrequency source. A solid state microwave

PROBLEM NO. 181 (Cont)

source incorporated in this design would be a major achievement. Further work and successful completion would be beneficial in many applications.

PROBLEM NO. 182: Pressure Gage, Low Pressure

Develop a pressure gage which will measure 10^{-5} torr and below and can be calibrated from fundamental constants.

BACKGROUND AND NEED: The only vacuum gage whose reading is dependent upon the geometry of the gage is the McLeod. In this gage the residual gas is compressed to full atmospheric pressure and the volume measured. The pressure is inversely proportional to the volume. Practical consideration of size limits this gage to measurements of 10^{-4} to 10^{-5} torr. Electronic gages which measure other characteristics related to pressure, such as ionization, electrical conductivity or thermal conductivity of the residual gas, are calibrated against the McLeod gage for their calculated response. The accuracy of this type electronic gage is not reliable. The inaccuracy of these gages become even greater when it is necessary to calibrate a gage at one pressure level and use it at another. Therefore, a gage that measures the number of residual particles in an absolute manner is needed.

PROBLEM NO. 183: Wire Welds, Verification Of, Nondestructive

Devise a nondestructive inspection procedure for verification of the quality of wire welds.

BACKGROUND AND NEED: It is the present practice to determine, empirically, the heat-pressure settings for welding given materials. However, repeatability is not guaranteed due to operator skill, electrode condition, electrode setting and metal condition. Present inspection methods which most accurately determine the quality of the weld are destructive. A method is needed which can be used, by relatively inexperienced personnel, to rapidly check the quality of welds in a nondestructive manner.

PROBLEM NO. 184: Antenna, Miniaturized

Develop miniaturized satellite antennas without loss of efficiency or impairment of electrical characteristics.

BACKGROUND AND NEED: Radio frequency experiments using satellites as an active source require the use of antennas that are efficient and possess the desired radiation pattern at the operating frequency.

The size of antennas for frequencies below about 100 megacycles becomes such that difficulty is experienced in attachment to the satellite while maintaining the desired electrical characteristics. As the frequency is lowered, it is necessary to utilize elaborate mechanisms to erect or "reel out" the antenna. Such arrangements seriously impair the versatility of operation.

Considering these and other facets of the problem, it is obvious that considerable advantage could be gained from an antenna that is miniaturized but retains all the electrical characteristics of a "full-sized" antenna. For example, a "full-sized" yagi at 50 megacycles is 3 meters across and several meters in length (the length is dependent upon the number of elements. If these dimensions could be significantly reduced and the directivity and gain be maintained, certain propagation experiments involving satellites would be greatly simplified.

PROBLEM NO. 185: Missile, Measuring Local Heat Transfer To Surface Of, In Flight

Develop a lightweight device for measuring local heat transfer to the surface of a missile in flight in the supersonic to the hypersonic range (Mach 5. 0) at altitudes where radiation rejection of heat cannot be neglected (40,000 to 100,000 feet). The device must disturb the boundary layer as little as possible; i. e., the wall temperatures must be maintained close to isothermal. Monitoring and associated telemetry circuits must be compact and unaffected by accelerations of up to 30 g's. The response time must be better than a hundredth of a second in order to follow the changing trajectory. The device must make and record data at a rate of 1 or 2 measurements per 30 second interval.

BACKGROUND AND NEED: Inaccurate results are obtained from present means of determining heat transfer rates in flight because

PROBLEM NO. 185 (Cont)

simplified assumptions are used (e. g., one-dimensional heat-sink skins, neglect of radiation, neglect of local anomalies introduced into the temperature behavior of the boundary layer by the presence of the recording device itself, etc.) or slow response time. Heat meter gages which employ monitoring thermocouples to regulate the amount of heat fed to the meter itself, to preserve isothermal flow, are extremely complicated, too heavy, bulky and expensive to be used on missiles, since they may not be recovered intact. It is necessary to obtain measurements of heat transfer under these particular conditions because no scaling laws are available for predicting how the rate of local heat transfer can be affected by protuberances or jet flows which interfere with the main stream. For the Mach number range of concern it has been found by wind tunnel studies that a factor of 12 can be present in the local value of heat transfer, when measured alternatively between situations for which there is or is not present a shock-producing disturbance.

PROBLEM NO. 186: Electromagnetic Energy, Transferred From Aircraft to Ground Measure

An instrumentation system is required for measuring the level of the electromagnetic energy which may be transferred from the aircraft to the ground plane (deck). The instrumentation system should be free from pick up effects and yield consistent and repeatable readings in the frequency range of 250 kilocycles to 300 megacycles and at power levels from milliwatts to 100 watts.

BACKGROUND AND NEED: To effectively conduct research and development work on the correction of aircraft radiation hazards, it is necessary to accurately measure the magnitude of electromagnetic energy which may be transferred from the aircraft to the ground plane as a result of parasitic excitation by adjacent RF transmitters. Due to probe pick up, available methods yield inconsistent and unreliable values.

PROBLEM NO. 187: Thermal Imaging Device, High Sensitivity

A high sensitivity thermal imaging device, employing electron beam scanning is desired. This device should be effective in the wavelength range of 1 to 10 microns.

PROBLEM NO. 187 (Cont)

BACKGROUND AND NEED: Mechanical scanning techniques are presently used in thermal imaging. To achieve improved performance and maintenance characteristics, a new approach is required.

PROBLEM NO. 188: Pulse Compression Techniques, Application Study Of

A study of the application of pulse compression techniques to active sonar devices should be undertaken.

BACKGROUND AND NEED: The application of pulse compression techniques to radar devices has provided significant improvement in detection capability. While a direct comparison of radar and sonar cannot be made, it is apparent that some of the advantages would apply. A study of the anticipated advantages against the disadvantages, such as reduced doppler information and equipment complexity, should be undertaken to determine the advisibility of undertaking development of equipments utilizing these principles.

PROBLEM NO. 189: Sensors, Animal Use To Detect Submarines

Investigate means to employ the acuity of animal sensors to detect submarines.

BACKGROUND AND NEED: It has been shown that senses of certain animals and fish are as high as a million times as sensitive as available electronics sensors. Studies on utilization of these animal sensors should be undertaken.

PROBLEM NO. 190: Copper Wire, Single Wire For Electrical Propulsion Of Submarines

Recent studies at NAV UNDERWATER ORDSTA have indicated that the use of high voltage dc electrical power transmitted over a single wire to a torpedo holds considerable promise of being an effective torpedo propulsion method. Successful development of this propulsion scheme hinges on the availability of insulated copper wire suitable of withstanding voltage gradients of at least 1000 volts per mil in 20,000 yard lengths and on the development of dc motors capable of operating with approximately 100 volts bar-to-bar

PROBLEM NO. 190 (Cont)

on the commutator. To reach this high voltage gradient without failure, the insulation may have to be applied in graded layers in order to distribute the voltage stress proportionately over the entire thickness of insulation. A motor requirement for this service would be as follows:

60 HP
4000 V dc
9 in. diameter
12 in. long
Single speed 10,000 rpm

PROBLEM NO. 191: Explosive Delay Elements, Improvement In Materials

An improvement in materials used in explosive delay elements is needed to prevent the change in characteristics that now occur during the first 6 months of storage.

BACKGROUND AND NEED: Production batches of delay mixes are currently uniform in characteristic but storage alters these characteristics with a resultant decrease in delay accuracy.

PROBLEM NO. 192: Piezoelectric Crystals

Develop piezoelectric crystals that exhibit no changes due to aging and temperature cycling after being in storage for 5 years.

BACKGROUND AND NEED: Presently, piezoelectric crystals must be pre-aged before storage to preclude any changes during storage. Pre-aging presents a cost factor that should be eliminated.

PROBLEM NO. 193: Surface Finish Of Small Areas

Devise a means of determining the surface finish of small areas, (.015 inch by .015 inch or less) in microinches (root mean square value).

BACKGROUND AND NEED: There is no way to determine the surface finish of very small areas. The immediate application of a solution

PROBLEM NO. 193 (Cont)

would be measurement of the finish on the faces of gears in miniature clock works such as fuze time delay gear trains. The range involved is from 16 to 32 microinches. Currently, the gear faces are buffed to remove burrs but very often the gears are deformed because there is no way of telling when the desired finish is reached. Another application would be the determination of finish in a .030 inch bore. Any means devised should not add more than $.10 to the unit cost of the gears mentioned above.

PROBLEM NO. 194: Fuze Time Delay, Fluid Escapement

Develop a means of utilizing fluid escapement as a fuze time delay (using damping principle). The fluid should have a freezing point of at least -65°F and a boiling point of at least 165°F at normal atmospheric pressure, a relatively small viscosity index, a small coefficient of thermal expansion, and should be compatible with normally used fuze materials.

BACKGROUND AND NEED: Existing fluids that have most of the necessary properties also have a high coefficient of thermal expansion.

PROBLEM NO. 195: Window, Transparent, Hermetic to Stainless Steel

Develop a transparent window, capable of good hermetic seal (leakage less than 10^{-6} cubic centimeter per second) to stainless steel. It must be insensitive to high frequency shocks such as would be produced by a small explosion next to the window.

BACKGROUND AND NEED: This window is needed in safety arming devices to protect personnel from explosion of the detonator. It is essential that the window be shatterproof since high confidence is necessary on the part of the personnel working with the fuze. Currently machined quartz is used but this is expensive and difficult to mount.

PROBLEM NO. 196: Material, Dielectric, For Missile Antenna Systems

Develop high temperature resistant (up to 5000°F) dielectric material for use in missile antenna systems. The material must be

PROBLEM NO. 196 (Cont)

suitable for joining to metals (similar coefficient of expansion). The system must cover the entire range of frequencies.

BACKGROUND AND NEED: Existing materials lose strength when subjected to aerodynamic heating or intolerable signal loss. Current materials used are ceramics, Teflon with fillers and, to some extent, fiber glass.

PROBLEM NO. 197: Vibrator To Operate In Heavy G Field

Develop a vibrator that will work well in as heavy a "g" field as is produced in a centrifuge. A random out is desired, although a sine output is acceptable. It should be variable from 0 to 2000 cycles per second with a force output of 10,000 pounds thrust. The driver may be pneumatic, hydraulic or electric.

BACKGROUND AND NEED: This vibrator will be mounted on a centrifuge arm for testing missile components. A need exists for a small, easily movable device as present vibrators are too large.

PROBLEM NO. 198: Cathode Follower, Semiconductor

Develop a semiconductor cathode follower with a minimum impedance of 1000 megohms, an output of 100 milliamperes, and a 1 minute time constant.

BACKGROUND AND NEED: This problem is concerned only with a cathode follower rather than an emitter follower which is not available.

PROBLEM NO. 199: Accelerometer Calibrator, Portable

Develop a portable (hand-carried) accelerometer calibrator for use in the field. It should be a self-contained (no external power supply) single pulse type. The pulse can be either explosively or pneumatically generated. The calibrator must produce repeatable pulses of 1/2 millisecond minimum; 2 millisecond maximum duration with a minimum amplitude of 2000 g's ±2 percent.

BACKGROUND AND NEED: This equipment would be used in the field to test pickup and associated wiring. The pickup would be disconnected from its test mounting but would not be electrically disconnected.

PROBLEM NO. 200: Bonding Wire Rope To Terminal

Develop a method of bonding wire rope to a terminal.

BACKGROUND AND NEED: Zinc is presently used to join wire rope to a terminal. This requires special equipment and correct temperatures which is not easily maintained on deck. A method is desired which does not require precision in application. Material used must not be affected by large temperature differentials and high impact shock.

PROBLEM NO. 201: Valves, Pressure Relief, High Flow Fluid (Liquid and/or Gas)

Develop high flow fluid (liquid and/or gas) pressure relief valves for pressures ranging from 2000 to 5000 pounds per square inch which will provide 100 percent seal upon reseating, and repeatedly relieve and reseat at preset pressures regardless of duration of relief discharge.

BACKGROUND AND NEED: Operational experience indicates that valves calibrated and set by manufacturers do not relieve or reseat at the pressure setting specified on valve nameplate and usually leak after operation.

PROBLEM NO. 202: Flywheels, High Inertia and Minimum Weight

Develop flywheels of maximum inertia and minimum weight by use of special materials and new design techniques.

BACKGROUND AND NEED: The development of suitable launching systems for use on advanced expeditionary and short field aircraft bases requires the use of optimum flywheels as part of their power plant systems. The vast amount of power required by these launcher installations necessitates optimization of these flywheel configurations in order to satisfy air transport, handling and installation requirements.

PROBLEM NO. 203: Clutches or Torque Transmission Devices Operating Under Difficult Conditions

Develop compact, lightweight, high capacity, minimum wear, clutches or torque transmission devices capable of operating under a wide range of slip. Torque output must be consistent from zero

PROBLEM NO. 203 (Cont)

to its maximum value. Torque values in excess of 500,000 pound-feet are required at the minimum slip (10 percent) condition. Maximum input speed is 2000 revolutions per minute.

BACKGROUND AND NEED: The torque transmission devices are required as a major element of a launcher power plant for use on advanced expeditionary and short field aircraft bases. The performance of the launcher hinges critically upon the torque transmission device having reliable and consistent characteristics. The lightweight and compactness of the device is required for air transport, handling and installation requirements.

PROBLEM NO. 204: Indicator, Steam Quality, Rapid Response

Develop a fast response steam quality indicator capable of recording nonsteady state changes in steam quality under conditions of varying pressure and temperature.

BACKGROUND AND NEED: This device is required in the study and development of steam catapult aircraft launching systems. An increased knowledge of this device would also improve catapult launching techniques aboard present day aircraft carriers.

PROBLEM NO. 205: Catapult Water Brakes, Measurement Of

Develop the following measurement devices for use with high capacity steam catapult water brakes:

a. A device for measuring the air content in the water and water-oil mixtures contained in a horizontal steel cylinder.

b. A device for measuring and continuously recording the velocity of the above mixtures.

BACKGROUND AND NEED: These devices are required in the development of high speed water brakes, An improved knowledge of the dynamic relationships of the variables involved is needed to properly evaluate various brake configurations. Since the cylinder is continually under simultaneously filling and discharging conditions, the fluid is in motion at all times. Velocities ranging from 2 feet per second to 1000 feet per second are encountered and must be

PROBLEM NO. 205 (Cont)

measured. The minimum natural frequency of the device noted under (b) above must be 25,000 cycles per second.

PROBLEM NO. 206: Gross Weight, Aircraft, Rapid and Accurate Method

A quick, accurate and simple method of obtaining aircraft gross weights prior to launching is needed.

BACKGROUND AND NEED: At present the weight is obtained by calculations based on the empty weight shown in the Weight Handbook for the aircraft. With catapult settings dependent upon aircraft gross weight and the gross weight depending upon fuel state and type of stores carried, there is considerable possibility of error. Actual weights obtained on the flight deck are of little value because of the effect of wind on the lift of the wings and the installation difficulties with accurate scales. If the weight is obtained on the hangar deck there is possibility of error with change in aircraft load.

PROBLEM NO. 207: Static Discharge Fogging of Roll Film

Investigate the underlying causes for the static discharge fogging of roll film exposed in aerial cameras and develop effective preventative measures.

BACKGROUND AND NEED: The phenomenon of static discharge in aerial camera roll film magazines manifests itself as light streaks appearing on the processed film parallel to the direction of film transport. These streaks make their appearance in a random, almost unpredictable manner and tend to obscure important image detail in reconnaissance photography. Some types of roll film as well as some types of film transport mechanisms are more prone to produce static marring. Environmental conditions are known to play a significant role in the appearance of static discharge streaks. What is needed is a comprehensive, analytical study of the conditions which favor static discharge; the potential sources which may generate those conditions and the development of an effective means of eliminating or controlling these conditions and sources. This study should serve as a guide for future development of aerial films and aerial camera equipment.

PROBLEM NO. 208: Barometric Altimeters; Improvements In

An improvement is still required in the readability and accuracy of barometric altimeters.

BACKGROUND AND NEED: For improved dependability, it is desirable to have a barometric altitude indicator that is operated directly from atmospheric pressure rather than depending on the aircraft's power. The old three-pointer altimeter, although accurate and dependable, is difficult to read. The counter-pointer altimeter used by the Navy has improved readability but may have higher error due to the high friction of the counters. In addition, the counter-pointer altimeter may give an erroneous indication when the last digit on the counter is changing.

PROBLEM NO. 209: North Reference, For Inertial Navigation System on Aircraft

A problem exists in the establishment of a north reference which is used for initially aligning the compass system in the inertial navigation system of carrier-based aircraft. The navigational accuracy of the overall system will depend a great deal on the accuracy of this initial setting. It is also important that the alignment be made rapidly and with little interference with the normal shipboard handling of the aircraft.

BACKGROUND AND NEED: In the past, the earth's magnetic field has been used for aligning the compass system of carrier aircraft after the aircraft has been airborne. In order to improve the accuracy of the self-contained navigation system, it is desirable to obtain a heading reference that is more accurate than can be obtained by using the earth's field. Two methods appear promising for improving the heading accuracy; one involves the use of a low drift directional gyro that is initially aligned to a north reference; the other involves the use of an inertial system that has gyro compassing capabilities. To use a low drift directional gyro, it is essential that the gyro be initially aligned with a high degree of accuracy (preferably less than 1/2 degree error) before take-off. If the inertial system could be accurately aligned in azimuth by an external means, the pre-flight time required for gyro compassing may be significantly reduced.

PROBLEM NO. 210: Cryostat, Lightweight Airborne Closed Cycle

Devise a small lightweight airborne closed cycle cryostat capable of providing at least 1/2 watt of cooling at 4 degrees Kelvin. The cryostat must weigh less than 20 pounds, require less than 1000 watts of electrical energy input, occupy a volume less than 1 cubic foot, and be capable of unattended operation for at least 500 hours without maintenance or servicing.

BACKGROUND AND NEED: Present infrared detection techniques require accessory cooling equipment which is burdensome in terms of weight, space, reliability and maintenance.

PROBLEM NO. 211: Airborne Moving Target Indicator

Develop an Airborne Moving Target Indicator (AMTI) for use in Airborne Early Warning Systems that provides a high degree of reliability without the necessity of frequent adjustment. Compensation for platform velocity should not require a clutter signal and should be free from blind speed limitations. It is desirable that the operator control permit the selection of velocities displayed.

BACKGROUND AND NEED: Present AMTI systems used with pulse coherent radars require frequent adjustment by highly trained operators. When operated over open sea, the absence of sea return prevents compensation for platform motion. Therefore, a new approach to the AMTI problem is needed.

PROBLEM NO. 212: Amplifier, X-Band, Special Characteristics

Develop an X-band amplifier with the following approximate characteristics:

a. Band width: 8.5 - 9.6 kmc
b. Peak power output: 10 kw
c. Average power output: 50 watts
d. Gain: 40 - 65 db
e. Phase sensitivity: less than 1 degree per 1 percent change in cathode modulation voltage
f. The output should be free from undesirable oscillation during slow rise and decay of the modulation voltage
g. The amplifier should be small, lightweight and rugged for use in airborne radars

PROBLEM NO. 212 (Cont)

BACKGROUND AND NEED: High resolution radars using pulse compression and programmed frequency techniques require broadband, high gain output tubes that maintain phase stability during the transmitted pulse. High gain travelling wave tubes, which are now available, are phase sensitive to modulation voltage and produce undesired oscillation during the rise and decay time of the modulation pulse. Modulators for these tubes are more complex and less efficient than magnetron modulators. An amplifying device that directly replaces a magnetron would permit modernization of many operational airborne radars. A device that approaches the magnetron size and has similar modulation requirements would permit the construction of new pulse compression radars to replace present conventional airborne radars.

PROBLEM NO. 213: Material, Sizing and Adhesion Enhancing For Glass Fibers

Develop a material to replace the sizing material and adhesion-enhancing material now employed in the manufacturing of glass fibers for use in plastic laminates and filament wound structures.

BACKGROUND AND NEED: When glass fibers are drawn, a sizing is applied to the glass to reduce damage from the rubbing involved in later process steps. If the fibers are to be used in plastic laminates or in filament wound structures, a chemical coupling agent must also be applied to the fibers to enhance their adhesion characteristics. At the present time, the fibers must be cleaned before the coupling agent is applied. The heat cleaning normally used leads to some degradation of fiber strength and the fact that the fibers must be cleaned increases the process cost.

A single material that would serve both as a sizing and a coupling agent is needed. Alternately, a coupling agent that could be applied over the sizing would be useful.

PROBLEM NO. 214: Hardness of Material, Determination Of

Develop a method of determining the hardness of a material without marring the material surface.

PROBLEM NO. 214 (Cont)

BACKGROUND AND NEED: A device is needed to determine the hardness of a material without damaging the surface. Sometimes a damaged surface can be a nucleus for a fatigue failure. Damaging the surface may also cause interference where mating parts are machined to a close tolerance. If the marred surface is a bearing surface, the roughened surface may cause further damage. It should also be noted that measurement of more than just the shell hardness is desired. The hardness of the surface plus some of the underneath material is required to give a true indication of the hardness of a material.

PROBLEM NO. 215: Torque Sensor, Engine Or Engine Reduction Gear

Develop a device for sensing torque of an engine or engine reduction gear.

BACKGROUND AND NEED: A device is needed which senses torque with an accuracy of ±2 percent for the upper values and ±4 percent for the lower values. The device is needed in connection with determining the torque output of a shaft of a gas turbine engine.

PROBLEM NO. 216: Drug To Control Effects Of Motion Sickness And Vertigo

Develop a drug which will control the effects of motion sickness and vertigo for pilots exposed to violent maneuvers at high speeds.

BACKGROUND AND NEED: Motion sickness and vertigo can seriously limit pilot effectiveness in space flights and maneuvering of high performance aircraft. At present, effective means to control this weakness in pilots is not available.

PROBLEM NO. 217: Beryllium, Purifying Of; Impurity Content Of Beryllium And Refractory Metals

Develop an inexpensive process for purifying beryllium in large quantities and a technique for accurately determining the impurity content of beryllium and refractory metals.

PROBLEM NO. 217 (Cont)

BACKGROUND AND NEED: Present methods for determining the qualitative and quantative purity of refractory metals are not as advanced as present purification capabilities for small quantity production of these metals. Although these metals are extremely pure metals, the small amount of impurities present greatly affect the ductility of the metals. In addition to this, new applications for beryllium require large quantities of this metal. The methods now used to purify the metal are either too expensive or produce too small quantities for wide application.

PROBLEM NO. 218: Coatings, Protective, For Refractory Metals

Protective coatings are needed for the refractory metals such as vanadium, columbium, molybdenum, tungsten, etc., which are subjected to extended (over 500 hours) stress applications at temperatures above 1800°F.

BACKGROUND AND NEED: During exposure to extremely high temperatures the surfaces of these metals form liquid oxides and drip away; therefore, necessitating some type of protective coating. Nonmetallic substances and mixtures of metals should be examined.

PROBLEM NO. 219: Sensor and Recorder To Display Partial Pressures of CO_2 and O_2

Develop a sensor and recording instrument which will discriminate and display values of partial pressures of CO_2 and O_2 contained in the limited space of an aircraft cockpit, space vehicle or pressure suit.

BACKGROUND AND NEED: Total pressures are easy to measure; however, the partial pressure analysis of the controlled atmosphere is a far more useful tool in analyzing the physiological aspects of the pilot's environment.

PROBLEM NO. 220: Reflection, Reduce or Eliminate, By Transparent Coating or Material

Develop a transparent material or a coating for a transparent material which will reduce or eliminate reflection on face plate of space helmet from radar scope or cockpit instrument lights.

PROBLEM NO. 220 (Cont)

BACKGROUND AND NEED: An acceptable material has not yet been found for elimination of reflection on the pilot's face mask. This reflection is the incidence of the pilot's own image in his view through the face plate while looking into a radar scope.

PROBLEM NO. 221: Torpedo Practice Intercept, Geometry Of

Develop equipment to accurately determine the geometry of a torpedo practice intercept. Although an instrument to provide a full determination of the intercept geometry is needed, the development of a proximity or miss-distance indicator would be satisfactory as a first step. In addition to this indicator, an underwater range tracking device, such as a TV scanner, to present torpedo run data by means of numerical readout with a parallel analog (video) presentation is needed.

BACKGROUND AND NEED: Present torpedo practice run instrumentation does not provide complete information on the relative location of the torpedo and target during the intercept phase of the run. This information is needed to make torpedo testing and evaluation accurate and efficient. Present instrumentation is often confused by the wake of either the target or the torpedo and provide erroneous data. Further, a method for range telemetry providing continuous tracking data and video observation torpedo test runs is not available. The problems presented by the environment of the sea, such as noise interference, limited visibility and inefficiency of electronics media, have prohibited the development of continuous tracking devices.

PROBLEM NO. 222: Valves, Liquid Rocket Fuel and Oxidizer, New Materials and Designs

Develop new materials, new designs or new methods for increasing the reliability of liquid rocket fuel and oxidizer valves.

BACKGROUND AND NEED: Valve seats have long been a big problem in liquid rocket motors performance. Valve materials subjected to extreme temperatures and pressures break down or wear down due to rapid opening and closing during operation of the motor. The effects of hard use are complicated by the existing condition of a vacuum in the nozzle area.

PROBLEM NO. 223: Rocket Motor, Pulse, Systems to Investigate Characteristics

Develop a system to instrument a pulse rocket motor which will provide accurate investigations of pulse characteristics, duration, and frequency. The instrumentation should measure flow and thrust for specific impulses and have the capability of monitoring pulse rates up to 10 cycles per second with great accuracy.

BACKGROUND AND NEED: No effective means now exists to instrument pulse rocket motors for a detailed physical study of internal motor operating characteristics and phenomena in terms of recorded data.

PROBLEM NO. 224: Missile Roll Control

Develop a highly reliable and accurate system of roll control of missiles by using fluid injection through the interior of the rocket motor nozzle to affect exhaust thrust vector direction.

BACKGROUND AND NEED: Present methods of roll control have made use of a four quadrant fluid ejection system. Where this method does provide a gross control against tendency of a missile to roll, there is not sufficiently fine control to dampen and stabilize the tendency to roll. The ideal situation would be a fluid injection system designed to inject the amount of fluid required into any quadrant segment within the 360 degree cone of the nozzle interior. This system would be under command of an instrument brain which would sense, correct and dampen the correction force continually to effectively fix the roll axis.

PROBLEM NO. 225: Guidance System, Inertial, General Purpose

Develop a general purpose inertial guidance system which will significantly advance the state-of-the-art in guidance systems for multiapplications through maximum accuracy, simplicity, reliability and accessibility for maintenance and repair. The dimensions and weight should be consistent with current and future planned applications.

BACKGROUND AND NEED: The present inertial guidance systems leave a lot to be desired in the way of designed accessibility to enhance the facility of maintenance and repair. The future demands

PROBLEM NO. 225 (Cont)

for overall guidance system performance requires a significant improvement in the state-of-the-art for design and production of highly accurate, reliable, simple systems for application in underwater weapons systems, launched weapons systems and space penetration systems.

PROBLEM NO. 226: Guidance System For Mobile-Launched Missiles

Develop a guidance system which has increased azimuth alignment capability for mobile-launched missiles.

BACKGROUND AND NEED: There is a great problem in accurately fixing horizontal position and alignment in terms of target intercept geometry for orientation of the missile guidance system in launchings involving a moving firing platform. Since there is no accurate fundamental azimuth reference, a system must be created which will make use of an equivalent reference such as celestial tracking, north seeking, etc. The system must be capable of solving the geometrical calculation of azimuth as a self-contained capability of the inertial guidance system of this missile.

PROBLEM NO. 227: Module, Welded Circuit Performance, Duplication Of

Develop a means of duplicating welded circuit module performance with standard components, or develop a means whereby welded circuit module components may be replaced and/or removed easily, in order to facilitate design of circuits of this type.

BACKGROUND AND NEED: At the present time, circuit designs are usually worked out using standard components and printed wiring boards or conventional breadboard wiring. They are then converted to the form in which they will be manufactured. This normally acceptable procedure encounters difficulties if the end product is to be in the form of welded circuit modules, since such modules introduce changes in circuit characteristics. One obvious way to solve this problem would be to do all circuit design in the form of welded circuit modules, but at the present time this is not practical because component changes cannot be easily made. Welded circuit modules usually are potted and removal of the potting compound (as the first

PROBLEM NO. 227 (Cont)

step in the removal of a component) often causes the module to collapse. A design tool or approach that adequately simulates welded circuit modules is required.

PROBLEM NO. 228: Attitude Serving Device

Develop an attitude serving device with the following characteristics:

a. Sensitivity: $1/2^{o}$
b. Cost: less than $1000
c. Operating life: seconds to 15 minutes
d. Frequency of use: 1 time
e. Size: 3 in by 3 in by 3 in maximum

BACKGROUND AND NEED: This instrument is to be used in missile testing, drones, and rocket probes. However, the main use would be in production missile guidance systems. Currently, the only thing available is elementary vertical gyros. These gyros cost $6000 and are too large in size. The unit, although intended for one time use must withstand several checkouts or be extremely reliable in order to dispense with checkouts.

PROBLEM NO. 229: Transducer, Altitude Rate of Change

Develop an altitude rate of change transducer that will give a direct readout of the rate with a sensitivity of 10 feet per second.

BACKGROUND AND NEED: Currently, the altitude rate of change is determined by differentiation of altitude versus time. Since altitude figures are inaccurate, this method leads to large errors. The system is needed for drones which receive no information after launching but climb to a preset cruise altitude. Presently, the drones oscillate wildly about the desired altitude. A pitch displacement gyro has been tried with success but the high cost of these ($5000) makes their use in an expendable item like the drone impractical.

PROBLEM NO. 230: Hydraulic System Components For Missile Use, Tolerance

Design hydraulic system components for missile applications that have the same tolerance as aircraft hydraulic system components now have.

BACKGROUND AND NEED: Presently, missile hydraulic components need exceptionally clean hydraulic fluid. Valves, in particular, are an area where extreme freedom from impurities is required. Present systems can tolerate a maximum particle size of 20 microns. It is desirable that the same fluid filtration system be used in supplying both missiles and aircraft in order to reduce expensive increases in service and maintenance complexity.

PROBLEM NO. 231: Torpedo Nose Section, New Material For

Develop a new material suitable for manufacturing torpedo nose sections. The new material should cause a minimum amount of distortion of beam pattern from an enclosed transducer and increase efficiency of hydrophones transmitting listening capability through the covering material.

BACKGROUND AND NEED: Present nose section materials cause distortion of beam pattern and razing of side lobes. Fiberglas is now used but it is far from the ideal material.

PROBLEM NO. 232: Hydraulic Fluid to Replace Ethylene Glycol

Develop a hydraulic fluid to replace the ethylene glycol (MIL-E-5559) currently used in arresting gear engines. This new fluid shall provide the same energy absorption and fire-resistant qualities as the existing fluid. In addition, it should have greater lubricity and incorporate improved corrosion inhibitors. This improved fluid should not exceed an estimated cost rise of 10 percent.

BACKGROUND AND NEED: Internal corrosion and excessive packing wear are two vexing problems encountered in the fleet in arresting gear installations. It is believed that substitution of an improved hydraulic fluid such as described herein could alleviate both of these problems.

PROBLEM NO. 233: Test Procedure For Arresting Engine Fluid

An adequate test procedure is needed to determine the suitability of arresting engine fluid for continued operation. This test should be satisfactory for application aboard ship by maintenance personnel and should give a definitive answer relative to the future service life of the engine fluid.

BACKGROUND AND NEED: At present, there is no reliable test to determine the degree of arresting engine fluid (Ethylene Glycol per MIL-E-5559) deterioration, (i. e., usage of inhibitors, ethylene glycol breakdown). At present, fluid is normally replaced at 2 year intervals, which may or may not result in optimum replacement depending on the degree of engine activity experienced during that operating period. This type of test, which is normally employed in any hydraulic system, as good maintenance procedure, should result in prompt discard of deteriorated fluid as well as retention of satisfactory fluid which would have been discarded simply on a time-elapsed basis.

PROBLEM NO. 234: Missile Velocity Measuring Device

Develop a missile velocity measuring device for use at missile test ranges.

BACKGROUND AND NEED: This instrument will be used to measure the velocity of missiles passing the device at an altitude of less than 1000 feet. Currently, radar is used to develop positions versus time data; the differential of this curve gives the velocity. However, radar cannot track missiles under 1000 feet so the system breaks down at this altitude. Infrared tracking devices should be investigated.

PROBLEM NO. 235: Microwave Filters, Compact, Tunable

Develop compact tunable microwave filters with a Q of 100 to 1000.

BACKGROUND AND NEED: Currently, applications in missiles use tuned cavities (tuned by servo motors). This approach leaves much to be desired. It is felt that a new approach is necessary to produce desired results approaching optimum.

PROBLEM NO. 236: Converter, Low Level Analog-To-Digital

Develop a low noise, low level analog-to-digital converter capable of high speed operation from a nanovolt input.

BACKGROUND AND NEED: This unit would be used to convert the type of analog signal available in the first detector of a radar set. A digital version of radar would permit more sophisticated signal processing with smaller systems. Present analog-to-digital converters cannot work from the low level of nanovolts without generating too high a noise level.

PROBLEM NO. 237: Microwave Energy Sources

Develop microwave energy sources of the following types:

a. Ultra stable, fast tunable source of microwave energy

b. Microwave energy source with 25 percent to 75 percent efficiency.

BACKGROUND AND NEED: The equipment currently used in missile and radar checkout and in the laboratory has to be very complicated to achieve stability. Additional equipment is needed to change frequency. A simpler unit is very much desired.

Currently, the efficiency of these units is less than 1 percent with regard to total power involved. The power source is quite limited in missile application and an increased efficiency would permit considerable missile improvement.

PROBLEM NO. 238: Pressure Release Material

Develop a pressure release material with a low temperature coefficient in the compressibility components. Accurate information on the materials currently available is also desired.

BACKGROUND AND NEED: Pressure release materials are used on transducer surfaces to prevent radiation in one or more planes. Where it is applied, the material mismatches acoustic impedance, making the transducer selective by limiting its area of conduction. Considerable hydrostatic pressure such as would be experienced by sonar transducers on submarines affects the acoustic softness of the material.

PROBLEM NO. 238 (Cont)

Since compressibility β varies inversely with the sum of pressure and a constant $\angle$ containing a temperature coefficient, a decrease in this temperature coefficient (currently 0.2 percent per degree in silicon, the best fluid available) would minimize the effect of pressure.

PROBLEM NO. 239: Potting Compound, Develop

Develop potting compounds as follows:

a. Low weight, high-strength. Strength range desired is beyond that of foams currently in use.

b. Foam potting compound with the following characteristics:

Handling time (mixing and pouring): 1.5 to 2.0 min.
Density: 2 to 20 lb/ft^3
Water Absorption: 0.9% maximum
Impact resistance: good
Compression strength: 375 lb/in^2 at 11 lb/ft^3
Uniformity (all size): 95% closed cells, minimum; 10% variation, maximum
Stress Index (temperature range from -70° to $185^{\circ}F$): 18.2 by 10^{-6} in./in./$^{\circ}F$ or better
Dielectric constant: 1.2 maximum (100 cps to 100 kc range)
Insulation resistance (1/4 in): 500 by 10^6 megohms
Dielectric strength: 85 volts/mil minimum

c. Potting compound with no microphonic magnification: coefficient of expansion approximately equal to that of the components and resistance to aging.

d. Potting compound that will withstand 12,000 feet depth of water with a storage life of 7 years.

BACKGROUND AND NEED: (Letter designations correspond to letter designations in the problem statement.)

a. Currently, glass beaded epoxy is used although it gives adequate structural support, its density is too high. Foams which are light in weight do not have the desired strength.

PROBLEM NO. 239 (Cont)

b. One of the polyurethane potting compounds now in use meets these specifications but it does not have a low enough exothermic characteristic (under 180°F) for the desired applications; encapsulation and potting of electrical and electromechanical components.

c. Of the present compounds, R. T. V. has good characteristics except for microphonic magnification; epoxy has an unsuitable coefficient of expansion, leads pull out of components at low temperatures and stipole is unsuitable at low temperatures (-65°F) and problems are encountered as it ages.

PROBLEM NO. 240: Boron Fibers, Binding Of

Develop a method of binding boron fibers together.

BACKGROUND AND NEED: A continuous boron fiber has been developed with excellent structural properties; e. g., strength of 750,000 to 1,000,000 pounds per square inch versus fiber glass, 500,000 to 700,000 pounds per square inch; modulus of elasticity, 68 by 10^6 versus 11 to 16 by 10^6 for glass; and a density of 2.34 versus 2.54 to 2.9 for glass. These excellent characteristics indicate many applications for boron fibers should the bonding problem be solved.

PROBLEM NO. 241: Electronic Switching, Contactless, Improvement

A state-of-the-art improvement is needed in the field of contactless electronic switching. Conventional toggle switches, rotary switches, relays and limit switches have only limited application when subjected to the high accelerations, pressures, temperatures and radiation encountered in present day weapon systems. For example, the best relay will currently take a shock of 10 g's while need exists for one that will take 1000 g's.

An electronic switch is needed that would have infinitesimal resistance when closed and infinite resistance when open. It should be RF radiation proof also.

All these components must be relatively stable under large environmental changes and rugged enough to withstand environments.

PROBLEM NO. 241 (Cont)

BACKGROUND AND NEED: There has been constant improvement of switches and relays. However, these components bearing moving parts and contacts have life cycle limitations as well as vibration and shock limits. Inspection to determine remaining life is difficult. There is a need to explore the possibility of using solid state and magnetic switching in circuits where conventional switches or relays are used. This would be developed into standard form factors suitable for high density modular packaging. They also could be packaged to replace conventional micromovement limit switches which are difficult to design into actuation systems. Static switch devices could be used in conjunction with sensing elements to provide circuit interruption for overload circuit protection.

Solid state relays are approaching the need of a contactless switch with a 0 to ∞ resistance change but they cannot be used in many applications. Presently, the resistance differential is 100 ohms to 1 megohm. Their decibel isolation at radio frequencies indicates that they are not true switches. Explosive switches fill many of today's needs but have a serious drawback in that they cannot be tested.

PROBLEM NO. 242: Inertial Navigator, Measure Distance Along Missile Trajectory

Develop a course inertial navigator to measure distance along the missile's trajectory with an accuracy in the range of ±10 to ±15 percent. The distance to be measured is on the order of 10 times the boost distance. The device must not be effected by gravity or orientation of the missile. Size should not exceed 10 cubic inches and not cost more than $500.

BACKGROUND AND NEED: Devices now exist that measure distances during the boost phase of a missile's trajectory. However, measurement of distances after glide begins is a problem, especially in low "g" missiles.

PROBLEM NO. 243: Heating System For Air-Launched Torpedo

Develop a heating system which could be built into an air-launched torpedo constructed of aluminum and reinforced fiberglas.

PROBLEM NO. 243 (Cont)

BACKGROUND AND NEED: A method is needed to heat air-launched torpedoes prior to launch. New aircraft will carry the homing torpedo at high altitude in an unheated bomb bay.

PROBLEM NO. 244: Torpedoes, Deep Recovery

Develop a method for the deep recovery of torpedoes. The system shall be external to the torpedo. A cost in the range of $5000 to $10,000 per recovery in deep water (greater than 250 feet and up to 500 feet) would be acceptable.

BACKGROUND AND NEED: Generally, an exercise torpedo is to be recovered. The location of the torpedo is a major problem. Work is underway on 2 vehicles, but so far full capability has not been achieved. Pingers now in use give about 2000 yards range for a few days time.

PROBLEM NO. 245: Submarine Target, Locating Of

Develop an inexpensive ($50,000) means of recording the location of a target submarine with regard to a reference point for a period of a few hours with an accuracy equal to 5 yards in depth and 25 yards in azimuth.

BACKGROUND AND NEED: This instrument would be useful in torpedo testing in a wide range of applications. The instrument shall be capable of being installed within a few hours and not require a permanent change to the submarine. DRT and submarine navigation equipment are now used, but the purpose of this equipment is not to provide high accuracy for a short time. Inexpensive SINS would be acceptable and also applicable to surface ships.

PROBLEM NO. 246: Graphite For Nozzles For Solid Propellant Missiles

Determine and specify the physical and chemical properties of graphite used for nozzles of solid propellant missiles.

BACKGROUND AND NEED: Graphite is now used for nozzles for solid propellant missiles and at present test results are the only

PROBLEM NO. 246 (Cont)

indication whether or not a specific manufacturer's graphite is acceptable. The need is for research in definition of graphite characteristics so that this material can be purchased using properly defined specifications as a guide.

PROBLEM NO. 247: Galvanometers Of Specific Frequency Response

Galvanometers used in oscillographic recording have a maximum frequency response of 5 kilocycles and require approximately 50 milliamperes per inch deflection. This requires use of amplifiers with very good characteristics; however, the frequency limit is still a problem. The need exists for a galvanometer with a frequency response of 10 kilocycles and a driving current of 50 microamperes.

BACKGROUND AND NEED: A galvanometer with these characteristics would eliminate the need for expensive instrument amplifiers as well as the noise problems introduced by these amplifiers.

PROBLEM NO. 248: Rocket Nozzle, Fabrication Of Porous Tungsten

There is a need for a new way to fabricate a rocket nozzle (exit diameter 5 inches and larger, throat diameter 1 inch and larger) out of porous tungsten. The porosity of the entire piece must be maintained at a uniform level.

BACKGROUND AND NEED: Pressing and sintering are used now but because of the complex shape, the process becomes very difficult and time-consuming. This factor is largely responsible for the high cost ($5000 to $10,000) per nozzle, while the cost should be only a few hundred dollars. The method developed should be adaptable to "one-of-a-kind" production and to full production of the final nozzle shape.

PROBLEM NO. 249: Tungsten, Cooling Technique

Develop a satisfactory way to keep tungsten cool.

BACKGROUND AND NEED: A method is needed to keep tungsten from melting at high temperatures. At present, the procedure is to infiltrate the tungsten with a metal such as aluminum or metals

PROBLEM NO. 249 (Cont)

with similar characteristics (i.e., low boiling point at operating pressures, and high heat of vaporization). This method is not satisfactory because tungsten and aluminum are soluble and the compounds which result from this condition are not very satisfactory. When tungsten and aluminum form a compound, the pores are not connected and the aluminum that vaporizes is trapped. A method is required to keep tungsten and aluminum from forming a compound. Uniform connected pores may be formed in the tungsten and then filled with aluminum.

PROBLEM NO. 250: High Temperature Measure

Develop an accurate method to measure high temperature, i.e., in excess of 3000°F, and up to 8000°F. The desired accuracy is ± 50°F.

BACKGROUND AND NEED: Currently thermocouples and optical pyrometers are used to measure these high temperatures. However, thermocouples have a limitation considerably lower than 3000°F. The optical pyrometer is accurate. Existing conditions during a high altitude simulation test, when it is desired, for example, to measure the rocket motor exhaust temperature, are such that the rocket motor is fired in a chamber. The pyrometer cannot differentiate between the temperature on the surface or in the flame because the area to be measured is obscured by fumes.

PROBLEM NO. 251: Coatings, Refractory, To Resist Spalling

Develop refractory coatings which will resist spalling from temperature, shock, etc., for application to the inside of combustion chambers of liquid propellant engine; protection of critical metal parts and adequate bonds which maintain integrity over the temperature range encountered.

BACKGROUND AND NEED: The coatings which are now available do not achieve good bonds when the temperature changes. The coating should be capable of being applied over complex shapes. The use of a bonding agent should be considered.

PROBLEM NO. 252: Coating Material Atomically Bonded, Resistant To Thermal Shock

Develop a coating material that can be atomically bonded to substrate and which will have good resistance to thermal shock. This coating is for application to several kinds of base materials (e.g., stainless steel, graphite) for the purpose of preventing erosion, melting, and chemical attacks of substrate.

BACKGROUND AND NEED: The present coatings are modified metal oxides of zirconium and similar metals. Newly developed coating material would eliminate many nozzle problems.

PROBLEM NO. 253: Procedure to Measure Propellant Mixture Consistency During Mixing

Develop a good procedure to measure the consistency of the propellant mixture while mixing is taking place. This procedure should include a means for determining the relative efficiency of the mixing processes and also a means for measuring control variables relative to materials in use. Presently, the accurate method for indicating when agitation of the explosive mix has produced a good mix does not exist. A good basis for sampling does not exist. It is necessary to determine exactly what information explosive testing is expected to produce before a basis for sampling can be determined.

BACKGROUND AND NEED: The method to measure the consistency of the propellant mixtures should be accurate, fast and remote because of the great sensitivity and energy involved in the new propellants. One current method is to measure the torque necessary to turn the mixer.

To determine the relative efficiency it is necessary to measure the miscibility of the various ingredients. This is a good means of simulating, from a sensitivity aspect, the forces involved in mixing.

PROBLEM NO. 254: Means to Determine Solidification Front During Casting of Explosives

Castable explosive systems use at least one liquid ingredient. During loading operations, a means to determine the solidification front in a cast explosive is needed, i.e., determine where the

PROBLEM NO. 254 (Cont)

interface exists between the solid and liquid when examination is made from outside the weapon. To accomplish this, it is necessary to go through 4 or 5 inches of explosive plus 1/2 inch to 3/4 inch of metal and locate the interface within an accuracy of 1/8 inch in a 3 inch section of explosive, i. e., 5 percent accuracy. The annular shape would especially require X-ray to pass through metal, solid, liquid, metal, liquid, solid. There is density change between the liquid (1.6 to 1.65 grams per cubic centimeter) and solid (1.75 grams per cubic centimeter).

BACKGROUND AND NEED: The need is real because control of the casting process now depends on experience and guesses. Defects in casting can be eliminated through control of the drying rate, etc. Much of the post-drying inspection could be eliminated if casting interface location versus time were known.

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